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THE DYNAMICS OF WATER CHLORINATION*

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[*Read September 16, 1947.*]

A complete study of the disinfection of water supplies by chlorine or any other chemical agent involves attention to many factors. Among these are: (1) the nature of the organisms to be destroyed and their possible concentration in water supplies; (2) the time of contact between the disinfectant and the organism; (3) the concentration and constitution of the chemical agent or agents liberated in the water; (4) the temperature of the water, and (5) the concentration and composition of the impurities present in the water that is to be disinfected. To cover all of these aspects of the problem of disinfection adequately requires an enormous amount of research. It is not surprising, therefore, that, despite the long history of the use of chlorine and its compounds for water-disinfecting purposes, not all of the significant factors are as yet satisfactorily understood even for this important disinfecting system. Programs of fundamental experimentation and analysis, inspired in part by needs of the wartime period, however, have given us a clearer concept of the quantitative relations of many of these variables to the total water-disinfection picture. It is the purpose of this paper to present the available fundamental information on what may be termed the dynamics of water chlorination.

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Water-Borne Pathogenic Organisms

The pathogenic organisms that should be considered in a study of water chlorination include (1) the enteric vegetative bacteria (*Eberthella, Shigella, Salmonella* and *Vibrio* species), (2) intestinal protozoa, of which the most important representative is *Entamoeba histolytica*, (3) worms, such as the cercariae of the schistosomes, (4) viruses—for example the virus causing infectious hepatitis—and (5) possibly spore-forming bacteria, such as *Bacillus anthracis*. Each of these groups of pathogens differs in its resistance to chemical disinfection, so that proper treatment for one of these groups of organisms is not necessarily adequate for water in which other types of organisms are likely to be encountered. Of the groups listed, the enteric bacteria are the most easily destroyed by ordinary chlorination procedures, whereas the cysts of *Entamoeba histolytica* and bacterial spores seem to be the most resistant organisms with which we have to deal. Where cysts may find their way into water supplies and the water is not properly filtered, concentrations of chlorine that are much higher than those employed in routine water-works practice must be added to ensure destruction of the cysts. As yet very little is known about the resistance of viruses to chlorination, but preliminary evidence indicates that the destruction of these ultramicroscopic infective agents may require somewhat higher concentrations of chlorine than those used for the enteric bacteria, although not necessarily so high as for the cysts of *E. histolytica*.

We may assume with Hoskins[1] that the coliform organisms discharged by an individual approximate 400 billion per day, and further with Kehr and Butterfield[2] that in a sewered area in which the annual typhoid rate is as high as 200 per 100,000 population, the ratio of *Eber. typhosa* to *Esch. coli* is about 1 to 10,000. Under these conditions, therefore, we must expect to find in excess of 100 *Eber. typhosa* per ml of concentrated sewage. Most of the work reported in this paper deals with 30 times this number of enteric bacteria but leaves out of consideration the barrier to disinfection presented by particles of fecal matter that may surround these organisms.

In reference to the expected concentration of cysts of *E. histolytica* in water, infected individuals are reported to discharge cysts in numbers varying from several hundred thousand to some ten million

per day. In an area of high endemicity, say 50% carrier rate, the ratio of amoebic cysts to *Esch. coli* would therefore be of the order of 1 to 100,000, or about one-tenth the relative density previously indicated for *Eber. typhosa*. This would make the expected number of cysts in concentrated sewage about 10 per ml. The concentration of cysts actually employed in the tests that underlie this paper was 3 to 6 times this value.

Chemistry of Water Chlorination

A fruitful approach to the problem of disinfection by chlorine and similar chemical agents is to regard the disinfection process as a chemical reaction between the disinfectant and some portion of the pathogenic organism. The studies should then be subject to the same type of analysis as are chemical reactions, and it will be shown that this is indeed the case in many instances. This approach requires that one have an intimate knowledge of the chemistry of the substance used as the disinfectant, in particular the reactions that it may undergo in dilute water solution. Since many active disinfectants react to form new chemical substances in dilute water solution, and since each of the substances formed has its own disinfecting characteristics, only a knowledge of the conditions under which each specific substance actually exists in the water will enable us to make an over-all interpretation of the results secured or to be secured. In particular will it be shown that changes in the efficiency of chlorine and its compounds with the acidity of the solution are to be interpreted quantitatively as a change in the relative amounts of the different disinfecting materials actually present.

Hypochlorous Acid and Hypochlorite Ion. When gaseous chlorine is dissolved in pure water to form a dilute aqueous solution, it reacts with water essentially completely to form HOCl and HCl. Even at 0° C. this reaction is complete in less than a second, as was shown by Shilov and Solodushenkov.[3] The hypochlorous acid formed is a weak acid and may further dissociate according to the reaction

$$HOCl \rightleftharpoons OCl^- + H^+,$$

the extent of the process depending on the final pH of the solution. The disinfecting agents present in chlorine solutions in pure water,

then, are HOCl and OCl^- ion, the former being far more active than the latter. Exactly the same disinfecting substances are present if solid or liquid hypochlorites are used (bleaching powder, calcium hypochlorite, Javelle water, etc.). Here the salt first dissociates to give hypochlorite ions and metal ions, followed by a combination of hypochlorite and hydrogen ions to produce undissociated HOCl, as shown by the equations

$$Ca(OCl)_2 \longrightarrow Ca^{++} + 2OCl^-$$
$$OCl^- + H^+ \rightleftharpoons HOCl$$

The relative amounts of HOCl and OCl^- ion present depend upon the ionization constant of HOCl and the acidity of the solution. Mathematically the relation is

$$\frac{[OCl^-]\ [H^+]}{[HOCl]} = K \text{ ion}$$

or

$$\frac{[HOCl]}{[OCl^-]} = \frac{[H^+]}{K \text{ ion}}$$

If one wishes to express this relation in terms of the analytical concentration of titrable chlorine, R, which is the sum of the HOCl and OCl^- ion, the equations are

$$[HOCl] = \frac{R}{1 + \frac{K \text{ ion}}{[H^+]}}$$

and

$$[OCl^-] = \frac{R}{1 + \frac{[H^+]}{K \text{ ion}}}$$

Values of the ionization constant for HOCl (at 0.01 ionic strength) obtained by a critical analysis of all existing data are as follows:

Temperature, °C.:	0	10	20	30
K ion	2.0×10^{-8}	2.6×10^{-8}	3.3×10^{-8}	4.2×10^{-8}

Substitution of these values in the previous equations shows that, below a pH of 6, practically all of the titrable chlorine is present as

HOCl and that, as the pH increases above 6, the fraction present as OCl^- increases rapidly, until at pH 10 and above practically all of the titrable chlorine is present as OCl^- ion. The actual variations are shown in Figure 1. Since analytical methods do not distinguish be-

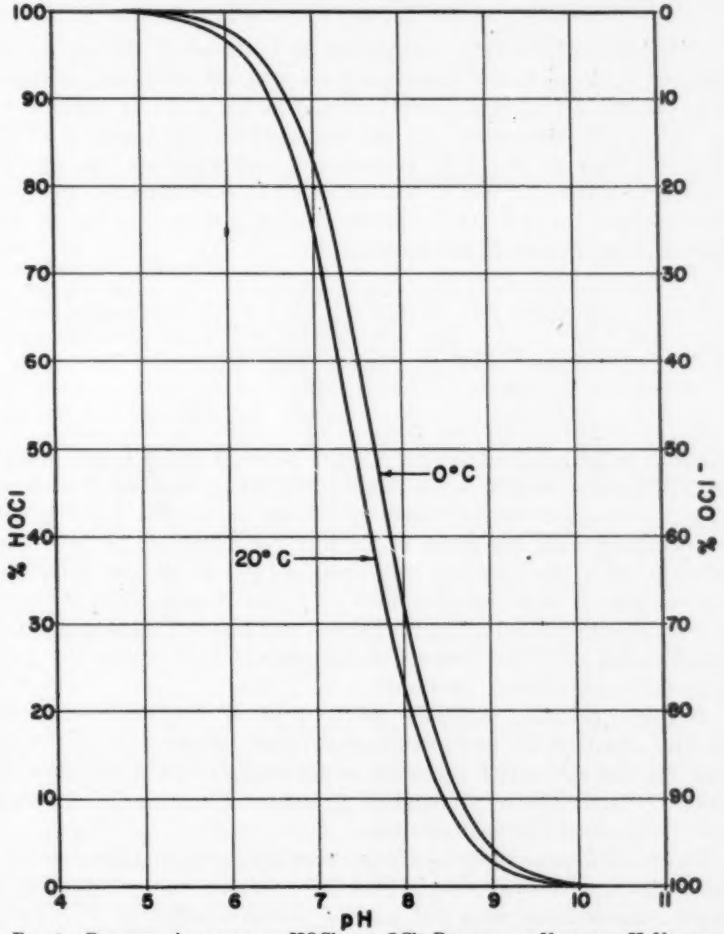

FIG. 1.—RELATIVE AMOUNTS OF HOCl AND OCl^- PRESENT AT VARIOUS pH VALUES.

tween HOCl and OCl^- ion, and since HOCl is a much more efficient disinfectant than OCl^- ion, titrable chlorine residuals alone are very poor measures of the disinfecting strength of a chlorine solution.

Application of Chemistry to Disinfection

Experiments on the destruction of cysts of *E. histolytica* by chlorine or hypochlorite solutions show that the evaluated chemical relationships are quantitatively reflected in the doses of chlorine required to kill these cysts. If one assumes that the effects of HOCl and OCl^- ion on the cysts are additive and expresses the relative efficiency of the OCl^- ion to that of HOCl as a constant, B, then one can calculate the cysticidal concentration of titrable chlorine for any pH value by means of the equation

$$R = A \frac{1 + \frac{K \text{ ion}}{[H^+]}}{1 + B \frac{K \text{ ion}}{[H^+]}}$$

where R is the required titrable chlorine residual and A is the amount of HOCl alone (expressed as titrable chlorine) required to destroy cysts. The experimental values of A and B for the experimental temperatures used are given in Table 1 for a contact period of 30 minutes and a concentration of 30 cysts per ml. It appears, therefore, that at normal water temperatures OCl^- ion is only about 0.2% to 0.3% as cysticidal as HOCl. In Table 2 and Figure 2 a comparison of experimental cysticidal doses with calculated values shows the good quantitative agreement obtained.

It should be noted especially that at a pH of 9, a value not infrequently obtained in water treatment (when water is treated with lime for the control of corrosion in particular), about 20 times as much residual chlorine is required to ensure destruction of amoebic cysts as is needed in acid solutions.

Exactly the same types of results were obtained in studies on bacterial spores. However, the pH of the solutions in the experiments under consideration were not carried above a value of 9. Conse-

TABLE 1.—COEFFICIENTS FOR THE EVALUATION OF CYSTICIDAL CHLORINE RESIDUALS
(30-minute contact period, 30 cysts per ml)

Temperature (° C.)	K ion $\times 10^8$	A (ppm)	$B \times 10^3$
3	2.2	7.5	6.1
10	2.6	4.0	4.2
18	3.1	2.1	3.2
23	3.5	1.2	2.5
28	4.0	0.7	2.2

TABLE 2.—DESTRUCTION OF CYSTS OF *E. histolytica* BY HOCl AND OCl^-

	Temperature, 3° C.							
pH value	5.0	6.1	7.0	8.0	9.1	9.9	11.0	
Experimental cysticidal residual, ppm	7.7	7.7	10.5	23.1	82.0	568	1150	
Calculated cysticidal residual, ppm	7.5	7.7	9.1	23.7	184	657	1145	
	Temperature, 10° C.							
pH value	5.1	6.0	7.0	8.0	8.9	10.0	11.0	
Experimental cysticidal residual, ppm	4.5	5.6	5.0	13.3	58.4	468	870	
Calculated cysticidal residual, ppm	4.0	4.1	5.0	14.2	79.5	499	873	
	Temperature, 18° C.							
pH value	5.2	6.0	7.0	8.6	9.0	10.2	11.2	
Experimental cysticidal residual, ppm	2.5	1.5	3.4	23.0	28.2	317	620	
Calculated cysticidal residual, ppm	2.1	2.2	2.7	27.0	61.1	402	617	
	Temperature, 23° C.							
pH value	5.0	6.0	7.0	8.0	8.7	10.0	11.1	
Experimental cysticidal residual, ppm	1.5	1.9	1.2	4.2	31.6	220	477	
Calculated cysticidal residual, ppm	1.2	1.2	1.6	5.4	21.3	225	440	
	Temperature, 28° C.							
pH value	5.1	6.0	6.8	7.0	8.2	8.8	10.0	11.1
Experimental cysticidal residual, ppm	2.2	1.3	0.8	1.1	3.6	12.8	174	280
Calculated cysticidal residual, ppm	0.7	0.73	0.88	0.98	4.4	17.4	149	269

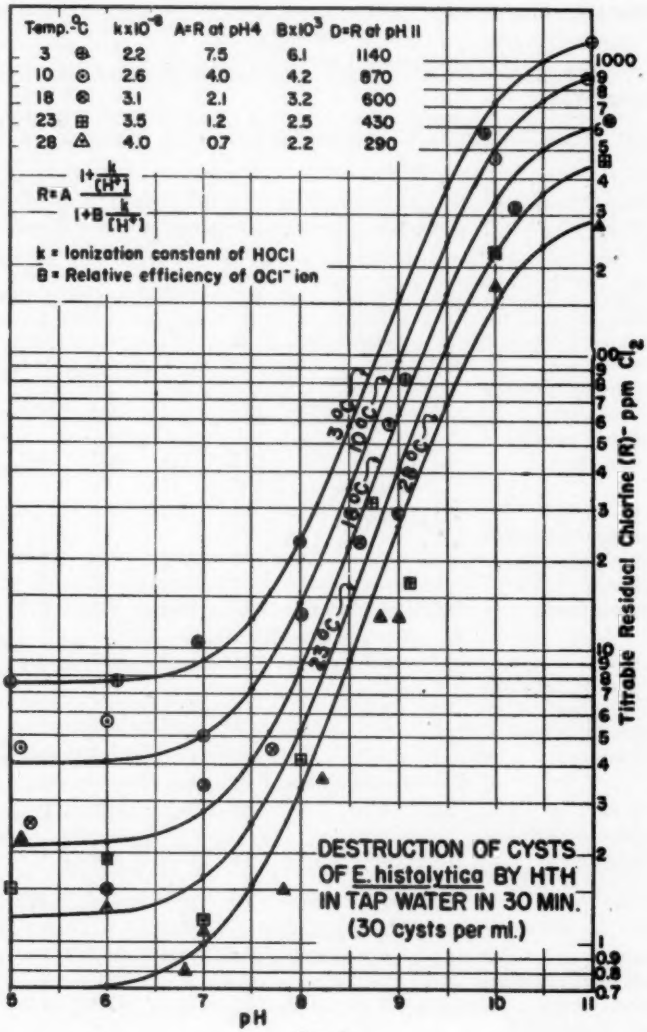
Temp.-°C
k x10⁻⁸
A=R at pH4
B x10³
D=R at pH 11
3 2.2 7.5 6.1 1140
10 2.6 4.0 4.2 870
18 3.1 2.1 3.2 600
23 3.5 1.2 2.5 430
28 4.0 0.7 2.2 290
R = A (1+k/[H⁺]) / (1+B k/[H⁺])
k = Ionization constant of HOCl
B = Relative efficiency of OCl⁻ ion
3 °C
10 °C
18 °C
23 °C
28 °C
DESTRUCTION OF CYSTS OF E. histolytica BY HTH IN TAP WATER IN 30 MIN. (30 cysts per ml.)
Titrable Residual Chlorine (R) - ppm Cl₂
pH

FIG. 2

quently the effect of OCl^- ion alone was not observable. The equation that may be used to evaluate the results is then

$$R = A\left(1 + \frac{K}{H^+}\right),$$

the symbols having the same meanings as in the previous equations. For a 30-minute contact period the values of A are 3 ppm for *B. anthracis* and 2 ppm for *B. metiens* at 25° C. The agreement of the results obtained with the theoretical curve is shown in Figure 3.

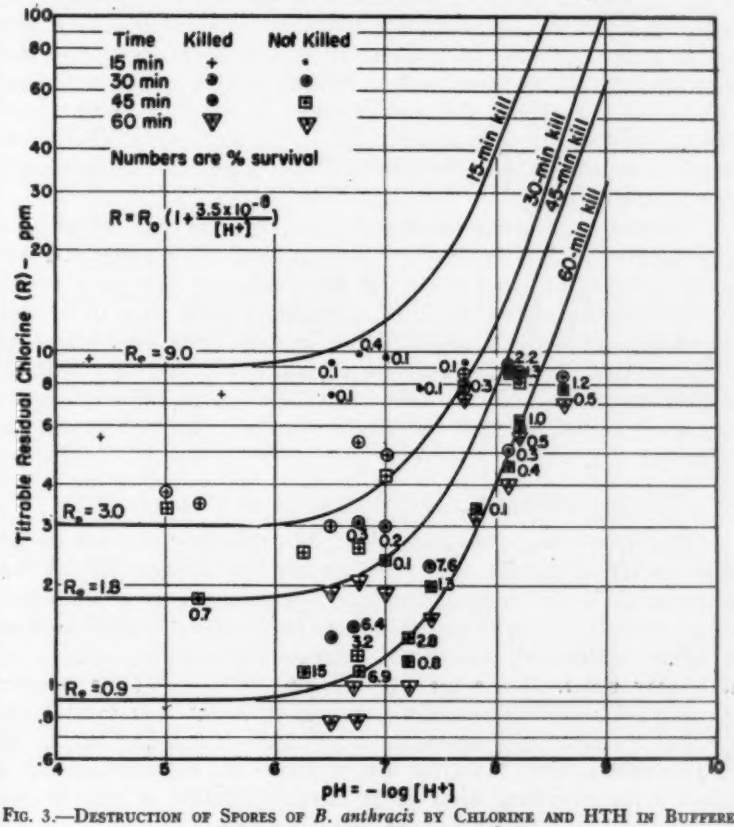

FIG. 3.—DESTRUCTION OF SPORES OF *B. anthracis* BY CHLORINE AND HTH IN BUFFERED DISTILLED AND TAP WATER AT 25° C.
(950 to 2050 spores per ml)

It has not been possible as yet to apply these concepts quantitatively to available information on the enteric bacteria, because of the quantitative difficulties involved in the experimental work and because of the relatively wide variation in resistance of bacterial cultures. Some calculations, based on the work by Butterfield, Wattie, Megregian, and Chambers[4] on the destruction of *Esch. coli* by HOCl and OCl^-, have been attempted by the authors of the present paper. The analyses have been carried out on the basis of the dose required to kill 50% of the organisms within 1 minute, since it was only for these conditions that sufficient data could be accumulated. The results obtained are shown in Figure 4 and are seen to agree reasonably well with the calculations. The required dose of HOCl is about 0.016 ppm of chlorine and about 0.75 ppm of OCl^-, so that the latter, under these conditions, is only about 2.2% as bactericidal as HOCl. At longer times the efficiency of the OCl^- ion approaches more closely to that of HOCl.

The cercariae of the schistosomes are reported to be killed by a residual titrable chlorine dose of 1 ppm in about 30 minutes, and this is also a reported requirement for inactivation of the virus of infectious hepatitis after removal of particulate matter. It is likely that only a portion of the titrable chlorine in these tests was present as HOCl, so that the results represent an upper limit for the resistance of these organisms to HOCl. The leptospirae causing infectious jaundice are even less resistant to hypochlorous acid than are the enteric bacteria.

Chlorine Demand and Formation of Chloramines

The disinfecting quantities of titrable chlorine that have so far been considered can be interpreted as required dosages only if the water supply is free of organic matter, ammonia and inorganic reducing compounds. In most natural waters two important side reactions of hypochlorous acid, which may increase the required disinfecting dose, may occur. These are (1) reactions with oxidizable organic or inorganic materials to reduce the hypochlorous acid to chloride and (2) reactions with ammonia or nitrogenous organic material to produce chloramines. Since the first of these—the chlorine demand—causes a corresponding drop in the titrable chlorine, it may be ac-

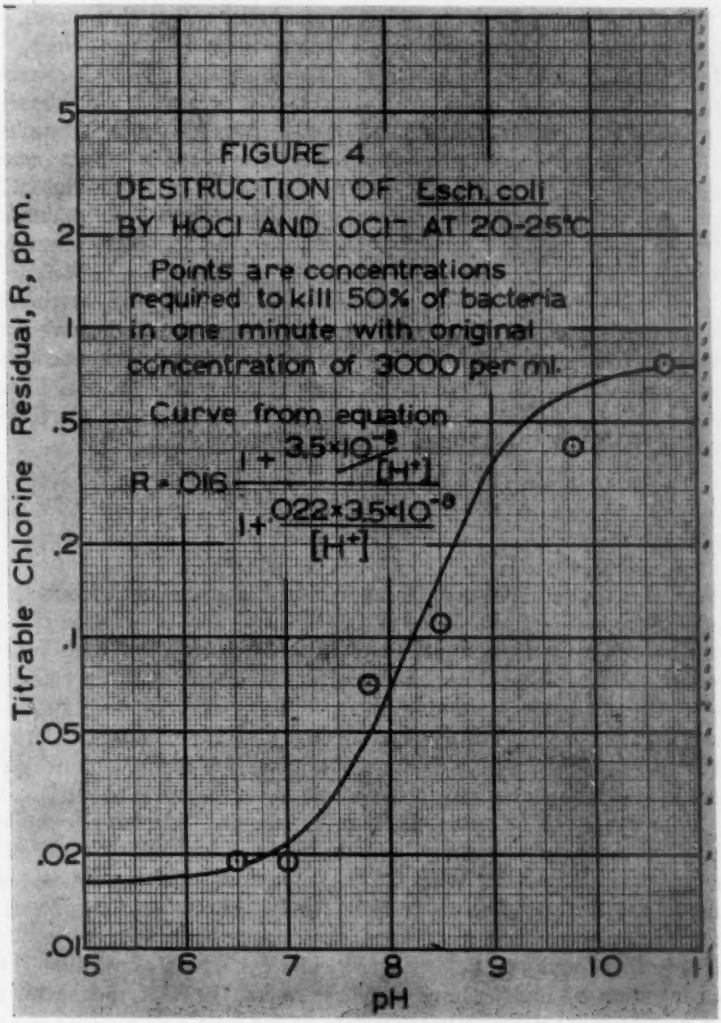
FIGURE 4
DESTRUCTION OF Esch coli
BY HOCl AND OCl⁻ AT 20-25°C
Points are concentrations
required to kill 50% of bacteria
in one minute with original
concentration of 3000 per ml.
Curve from equation
$R = .016 \frac{1 + \frac{3.5\times10^{-8}}{[H^+]}}{1 + \frac{.022\times3.5\times10^{-8}}{[H^+]}}$
Titrable Chlorine Residual, R, ppm.
5
2
1
.5
.2
.1
.05
.02
.01
5
6
7
8
9
10
11
pH

FIG. 4

counted for by maintaining chlorine residuals, rather than doses, at the previously discussed levels. The formation of chloramines, on the other hand, causes no loss in titrable chlorine but, since it changes the chemical form in which the disinfectant is present, it also changes the disinfecting characteristics of the solution. To have complete information, the disinfecting action of all possible chloramines needs to be studied in the same way that the efficiencies of HOCl and OCl^- ion have been investigated. So far, only the ammonia chloramines—monochloramine (NH_2Cl) and dichloramine ($NHCl_2$)—have been investigated in this fashion.

Results obtained for the destruction of amoebic cysts by chloramines at 23° C. are shown in Figure 5. The calculated curve was obtained from the results of Chapin[5] on the amounts of monochloramine and dichloramine present at various pH values plus a linear combination of the efficiencies of the two materials, just as for HOCl and OCl^-. The resulting general equation is

$$D = \frac{A}{N + (1-N)\frac{A}{B}},$$

where D is the required disinfecting residual, and A is the disinfecting residual for dichloramine alone and B that for monochloramine alone, both expressed as titrable chlorine. These results show that, for a contact time of 30 minutes, dichloramine is about 60% as efficient as HOCl and monochloramine about 22% as effective. Because of the formation of the relatively ineffective OCl^- ion in free chlorine solutions at high pH values, the chloramines are actually more efficient cysticidal agents than free chlorine above a pH of about 7.5.

For spores of *B. anthracis*, dichloramine was relatively less efficient, having only about 15% of the disinfecting ability of HOCl for a 30-minute contact period. The sporicidal efficiency of monochloramine, furthermore, was so low that its effect could not be detected in the experiments performed. Calculations based on the results of Butterfield and Wattie[6] with the enteric bacteria show that the concentration of dichloramine required to kill 50% of the bacteria in 1 minute is 80 to 100 times as great as for HOCl. No disinfecting activity of monochloramine could be detected. Studies with other

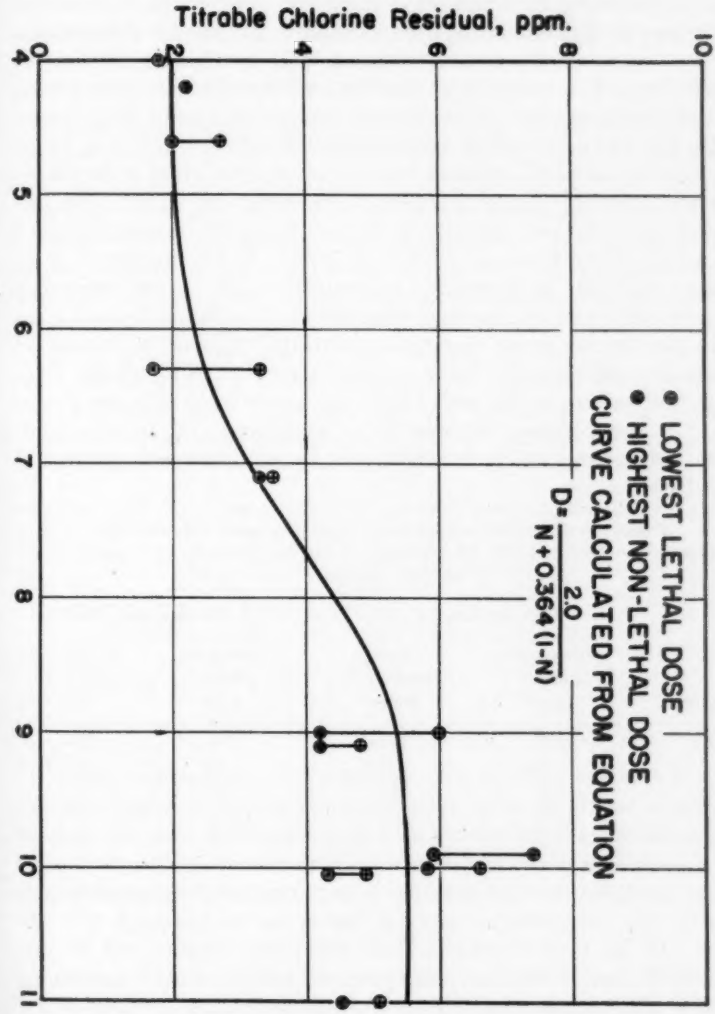

FIG. 5.—DESTRUCTION OF CYSTS OF *E. histolytica* BY CHLORAMINES IN 30 MINUTES AT 23° C.
(30 cysts per ml)

types of pathogens have not yet reached the point where it is possible to distinguish disinfection by free chlorine from that by chloramines.

By means of the results obtained it is possible to predict the disinfecting action toward cysts for any solution in which, from chemical consideration, the concentrations of hypochlorous acid, hypochlorite ion, monochloramine and dichloramine are known. It is hoped that similar complete relations can be set up for other water-borne infective organisms, as experimental knowledge increases. The calculation is carried out very simply by translating the results described into a "Cysticidal Constant," which is defined as the number of liters of water that can be disinfected by destruction of a given concentration of cysts under the specified experimental conditions by one gram of the disinfecting agent (measured as titrable chlorine in the case of the present substances). Table 3 shows a number of Cysticidal Constants determined in this way. They are given for a cyst concentration of 30 per ml, since this was the standard employed in the experiments. Obviously, similar constants can be set up for any concentration of cysts.

TABLE 3.—CYSTICIDAL CONSTANTS FOR CHLORINE COMPOUNDS
(Liters of water in which 30 cysts per ml can be destroyed by 1 gram of titrable chlorine)

	Temperature, 23° C.		Temperature, 3° C.	
Substance	10-minute contact time	30-minute contact time	10-minute contact time	30-minute contact time
HOCl	270	833	50	160
OCl^-	1.1	2.1	0.5	0.81
$NHCl_2$	170	500	—	130
NH_2Cl	—	182	—	42

Calculations involving these constants are straightforward. One simply multiplies the concentration of each reagent (in ppm of titrable chlorine) by its cysticidal constant and sums the products thus obtained. If the total is greater than 1000, the solution will be disinfected; if less, it will not. For example, with a solution containing 2 ppm of dichloramine and 2 ppm of monochloramine, the total at 23° is $500\times2+182\times2=1,364$; hence the solution is cysticidal in 30 min-

utes at this temperature. But at 3° the result is $130\times2+42\times2=344$; consequently, under these conditions the cysts will not be killed.

Time-Concentration Studies

Only brief mention can be made of experiments on some of the other variables that were enumerated at the beginning of this paper. The time-concentration relation is of importance, since two disinfectants that are equally potent at one concentration may have quite different efficiencies at some other concentration. The relation for any one substance is generally expressed by the equation $k=C^n t$, where n is a positive number expressing the relation between the concentration of disinfectant, C, and the killing time, t. If n is large, then the killing time varies very sharply as the concentration is changed, while if n is less than 1, then the concentration is relatively less important than the time. Several values of n for different pathogenic organisms are shown in Table 4 for the various chlorine compounds.

Table 4.—Time-Concentration Relations for Chlorine Compounds

Substance	Value of n			
	Cysts of *E. histolytica*	Enteric bacteria	Spores of *B. anthracis*	Spores of *B. metiens*
HOCl	1.00	1.6[4]	0.67	0.90; 1.0[7]; 0.95[8]
OCl^-	2.0	0.75[4]	—	——
$NHCl_2$	1.0	0.75[6]	0.80	0.8[8]
NH_2Cl	1.0	—	—	——

These differences in the values of n indicate differences in the process controlling disinfection. Coupled with the temperature studies that are still to be discussed, it is hoped that they may lead to a more intimate understanding of the way in which pathogens are destroyed by disinfectants.

Temperature Effects

As with the great majority of rate processes, the efficiency of disinfectants decreases with decrease in temperature. This temperature effect may be expressed either as Q_{10}, which is the geometrical

increase in disinfection rate for a 10° C. rise in temperature, or as E, the activation energy for the process, expressed in calories and derived from the equation

$$\frac{d \log R}{dT} = \frac{E}{4.575T^2},$$

where R is the rate of disinfection and T is the temperature in absolute degrees. In place of R, one may substitute the reciprocal of the time required to disinfect at a given concentration. Values of E and Q_{10} for the killing of various infective agents by chlorine compounds are shown in Table 5.

TABLE 5.—TEMPERATURE COEFFICIENTS OF DISINFECTING REACTIONS FOR VARIOUS INFECTIVE AGENTS

Substance	Amoebic cysts		*B. anthracis* spores		*B. metiens* spores		Enteric bacteria	
	E	Q_{10}	E	Q_{10}	E	Q_{10}	E	Q_{10}
HOCl	14,000	2.4	5,200	1.4	11,800[8]	2.1	——	—
OCl^-	15,000	2.5	——	—	——	—	——	—
$NHCl_2$	11,000	2.0	——	—	20,400[8]	3.1	10,500[6]	1.9
NH_2Cl	12,000	2.1	——	—	——	—	——	—

The activation energies are seen to range in general from 10,000 to 15,000 calories, values that are about the same as the activation energies for many oxidative biological processes.

MECHANISM OF DISINFECTION

The foregoing and other studies by the authors have indicated that the factor determining the difference in resistance of different types of organisms and a portion of the difference in efficiency of the various halogen compounds may be correlated with the resistance of the cell wall to diffusion. From this point of view, the greater resistance of cysts and spores to disinfection, as compared with bacteria, is accounted for by the thickness and resistance to diffusion of the cyst or spore wall, as compared with the bacterial membrane. The differences in efficiency of HOCl and OCl^- ion with respect to cysts and spores can be attributed to the relative ease of diffusion through the cell wall of neutral molecules, as compared with negative ions.

Where penetration is relatively easy, as is true for the enteric bacteria, the differences seem to be concerned principally with the reactivity of the particular disinfecting agent with some vital portion of the pathogenic organism. Even in these cases, however, diffusibility probably determines the disinfecting action to some extent.

Conclusion

Studies of the dynamics of the disinfection process are of fundamental importance in paving the way for more reliable sanitary control of water supplies. Only by a thorough knowledge of the basic factors affecting the destruction of pathogens can disinfection be converted from a trial-and-error procedure to sound scientific practice. As further information is gained as to how and why organisms are destroyed, the way may be opened to the discovery of new and more efficient disinfecting materials.

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WATERSHED PRACTICES OF BRIDGEPORT HYDRAULIC COMPANY WITH PARTICULAR REFERENCE TO AERIAL WATERSHED SURVEYS

BY FREDERICK B. SILLIMAN*

[*Read September 16, 1947.*]

Bridgeport Hydraulic Co. is a stock corporation and is owned by over 3,000 stockholders. It is engaged in the business of collecting, purifying, selling and distributing water for public and private consumption in the city of Bridgeport and the towns of Westport, Shelton, Fairfield, Stratford, Trumbull and Easton, all of which are located in Fairfield County, Connecticut. The population of the communities served is estimated at 250,000 persons. We are currently supplying this community with an average draft of 37 mgd.

The physical properties consist of several systems of distribution, storage and diverting reservoirs, which supply water by gravity to the community. There are six high-elevation districts, which are supplied from storage tanks, to which the water is carried by electric pumps. We have a total of ten reservoirs. Four of these—Hemlocks, Trap Falls, Easton and Shelton #2—supply water directly to the distribution system. Two others—namely, Saugatuck and Shelton #3—are storage basins which feed into the Hemlock and Shelton #2 supply. The other four are diversion and collection reservoirs.

The four main reservoirs have a combined total capacity of 24 billion gallons, of which approximately 20 billion are available for use. The water for these reservoirs comes from a watershed area of 91.2 sq mi. Bridgeport Hydraulic Co. owns outright 31.2 sq mi of this watershed, or 34.2% of the drainage area.

Watershed Management

The watershed area owned by the Hydraulic Co. and the land, buildings and physical properties thereon are under the supervision of engineers and men who are trained in various other fields.

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There are care-takers on all of the reservoirs, who have varying numbers of men working under them, depending on the size of the reservoir and the type of work to be done. They are responsible for clearing underbrush, mowing the flow lines and patrolling their immediate area for trespassers. During the winter months many are engaged in working in the pine plantations. At the four distributing reservoirs, we have chemical treatment plants and the care-takers on these reservoirs are also responsible for their maintenance.

All the care-takers and many other watershed employees live in company-owned houses. We have found through this procedure that we always have men available for any emergency that may arise and the men themselves have a feeling of job-security. We also encourage participation in the town activities as a means of fostering good public relations. For example, one of the care-takers is also Fire Chief in the town of Easton and many are Fire Wardens in the towns in which they live.

In comparison with most water companies, we own a much larger number of acres on our watershed area. We have done this with a purpose. The only way in which Bridgeport can expand is towards the outlying areas, where our reservoirs are located. Therefore, we have felt a community obligation to purchase land in these towns as a means of protecting the water supply of the future.

In order to get some small return on all the acreage we own, we have developed a large apple orchard, set up a small saw-mill, established a small nursery and reforested large areas with conifers, some of which are thinned and sold for Christmas trees each year.

Our nurseries and orchards are under the supervision of a college-trained agricultural expert. The first plantings of pines were set out roughly 30 years ago and we have been setting them out yearly ever since. It has been very interesting to watch these stands develop and some of the trees have now reached a size where they can be economically lumbered. In addition to the timber value, these trees protect the land from erosion, prevent decaying leaves from blowing into the water and eliminate a certain amount of mowing around the water lines. They also present a very pleasing appearance and we find that many people spend their Sundays driving through the country to see the beautiful landscape that has been developed.

We have found from experience that the white pines are the most satisfactory to plant in this climate. We have had infestations of white-pine blister rust, some white-pine weevils and a few harmful bark beetles, but none have proven serious. The red pines, which we also planted, have been seriously infested with European pine-shoot moths and of late by a very serious scale, which had not formerly been known to this or any other area. The remaining pine species which were experimented with have proved of little worth and their future planting has been abandoned.

We have also planted spruces and some firs. Some of these have been satisfactory and others have not. Plantings of this nature have, however, brought in considerable revenue upon being thinned and sold for Christmas trees. We have established our name in this field locally and nearby residents will travel to our barns year after year to pick out freshly cut trees.

Some years ago we established a nursery of the more common ornamental species for the retail trade. This development went on for a few years but met with some opposition from local nurserymen, who did not like a public utility company for competition. As a result of this, we departed from the retail field and now sell wholesale to the retail dealers themselves. This has been mutually beneficial, as the average retail nurseryman does not have available land for the growth of medium- and large-sized specimens of trees.

Our apple orchard covers an area of 210 acres. Some acres have produced as many as 600 bushels to the acre. Our peach orchard is small and, like all such orchards in this area, the yield is not too reliable. At our barns in Easton we have a cold-storage unit, where the apples that cannot immediately be retailed are kept until they can be sold on the local or New York market.

We have recently set up a new sawmill, which enables us to use our own lumber. A box-shop is now being set up, where we will be able to construct apple boxes from pine thinnings. With the present high cost of lumber, any boards and rough timber that we can turn out ourselves save a considerable amount of money.

A permanent sanitary engineer was employed in 1942, to patrol the watersheds and make sure that no pollution was entering the streams. The only watershed maps available at that time were drawn on U. S.

Geological Survey maps. It was felt that the watersheds drawn on these maps, which were made in 1889, did not in all cases correspond with the exact watershed lines in the field. This could easily be understood, because the maps themselves were of such a scale that a very slight difference in the interpretation of the contours could result in a very large error. Therefore, it was decided that a more exact means of determining the watershed lines would have to be developed.

Aerial Surveys

The solution which we finally found was the use of aerial maps which had been made for this area. The scale of these maps was 1 in. = 1200 ft, which we found satisfactory for plotting the exact lines. In order to find these lines accurately, it was necessary to take the individual maps, measuring 6 in. by 8 in., into the field. Our Engineer spent two winters developing these lines in the field. He actually took the aerial maps and walked every foot of the watershed lines, marking them on the maps as he went. This was really a fill-in job and was done in the winter-time, when the leaves were off the trees and the break-points were more easily determined. After you work with these maps for a while it is easy to locate yourself at a glance. In dense wooded areas, large boulders, conifers and swampy areas are the usual landmarks for which to look. With some experience a man can cover up to four lineal miles on the line daily.

The lines, as determined on these small-sized maps, were then transferred to a large aerial map, covering the entire watershed. From this map the exact area can be readily determined. After this survey was completed, it was found that an additional watershed area of approximately 4 sq mi was included. For companies that are considering expanding their facilities, an aerial survey such as this would be extremely valuable and very accurate in determining the watershed areas available.

We have found this aerial survey aided us greatly in determining whether certain houses were on the active watershed. At least 25 houses were found to be on the shed which had previously been thought to be of no interest to us. It is felt that, if this survey did no more than discover these houses which were violating the sanitary laws, all the effort was worthwhile.

The survey also has proved very useful for general reference to the main office. If any questions arise as to whether a certain house or a piece of land is on the watershed, a quick glance at the map gives the answer. The aerial map is easily read by a person who has never visited the area involved. This means that an "inside man" can tell what is going on "outside" without stepping out of the office. This has been proved many times when the company is considering the purchase of a piece of land in the country. We are able to determine what shed the land is on, where it is, and how much water there is on the parcel. Once the watershed line has been determined on these maps, it is a permanent feature. Therefore, whatever the initial cost is for the maps can be considered a life-time investment.

We also use U. S. Tactical Maps, available from the Army Map Service. These are contoured and have a scale of 2½ in. to 1 mi. The company has prepared a large wall-map, showing the reservoirs, watersheds and land owned, so that the entire holdings may be seen at a glance.

Sanitation of Watersheds

Our Sanitary Engineer maintains constant vigil over the watersheds and periodically inspects all houses that could in any way contribute to contamination of the water supply. When a new house is being constructed, the owner is contacted and the rules and regulations governing sewage disposal on a watershed are explained. To be sure that there are no misunderstandings, a letter outlining the requirements is sent by registered mail. A copy of the State Sanitary Regulations is always enclosed.

The responsibilities placed on a company sanitary engineer are somewhat different from those of a state or local health officer. In addition to seeing that the laws are not violated, the company man must try to maintain and develop good will. This good-will item is considered by us to be extremely valuable for a great many reasons. If the public is properly informed of what you are doing and the reasons for your actions, the resulting coöperation is much greater. Most people are under the impression that utilities have lots of money and are really out to "get" them in any way they can. If this impression is not kept in check, working conditions become most difficult. The notions that some people develop are really surprising.

When sanitary conditions are found to be unsatisfactory at any location, our present policy is as follows:

If a house was built prior to the active use of a watershed, we construct and maintain the sanitary disposal units at our own expense. After sanitary units are installed, any required changes due to additions or plumbing changes are up to the owner. That is, if we construct a privy vault and, at a later date, a bathroom is installed, it is up to the owner to install the proper sanitary disposal units.

Any new house constructed on the watersheds must install proper sewage-disposal units at the owner's expense. As stated previously, the owner is advised of the governing rules and regulations. We also aid the owner by giving him information on suitable disposal units, so that he will have the facts and have no excuse for installing a poorly designed system. This free advice pays dividends as times goes on, as the sewage-disposal systems function correctly for a longer period of time and do not become a potential hazard to the water supply. Our chief difficulty comes from speculative builders, who put in the cheapest possible systems.

On occasion, we will install a system for people when they cannot afford a suitable system. We also split the cost of systems, when we know that ground conditions are so poor that the cost of a well-designed system will be prohibitive to the owner.

You might wonder if we are not spending too much for this sort of work. We find from experience that, if a person is forced to install a system, it will many times be of cheap construction and inefficient. What we are striving for is lasting, good sanitary conditions on the watershed and, by installing systems ourselves, we get the results we want.

We have found that the most lasting and efficient system for dwellings with toilet facilities, located on the watersheds, is a well-designed septic tank with proper field disposal for the effluent. Most of the locations we encounter are near water and the area available for disposal is small. As a result, complications often develop and, in many cases, combinations of disposal units must be used. The design of any individual system must take into consideration location with respect to well, topography, water table, soil conditions, area available and maximum living capacity of the dwelling.

The septic tanks installed are of concrete with reinforced-concrete tops. Their capacity is based on the number of persons that could occupy the dwelling at any one time. We never construct a tank with a liquid capacity of less than 500 gal. Leaching trenches are generally used to handle the effluent from the septic tank. These have cross-sectional dimensions of 3 ft by 3 ft or larger, as the situation demands. They are laid up with field stone on either side of the trench and capstones are placed on top. Reinforced-concrete covers are used where vehicular traffic is expected over the trench. This leaves an opening in the center, which handles the sewage in a manner similar to an open-type cesspool or leaching well. The advantage of this unit is that in wet ground, where the water table is high, the maximum area of absorption can be developed. The absorption area to meet requirements is regulated by the length of the trench installed, the cross-sectional dimensions and the land area available.

After a system is constructed, the Sanitary Engineer makes a permanent record of the installation. All units are located by measurement and recorded in the main office.

Once a year the State Board of Health sends a sanitary engineer to visit all locations on the watersheds that are potential sources of pollution. When they make this survey our own sanitary engineer accompanies the state official—to relate changes that have taken place during the year and present whatever new problems have arisen. Naturally, this annual inspection trip tends to keep us on our toes during the year. However, we derive definite benefit from this visit, as the appearance of a State Board of Health inspector is sometimes all that is necessary to get an uncoöperative party to coöperate. We have been very fortunate in Bridgeport to have F. A. O. Almquist as the Field Engineer who visits us annually. These men are also available during the year, whenever we need to call on them for help and advice.

Color of Water

In the year 1942 a color survey was started, to determine why the water from the Trap Falls system was above average in color. The color had been steadily increasing, until it had reached a point well above the average for similar supplies in the state.

The color survey was undertaken to locate sources of high color, so that they could be eliminated or improved in some way, through ditching and gate control. Several of the more important brooks and rivers on the various sheds were selected for sampling. The collection points were picked to give characteristic color of the stream and were nearly all at the terminus, where possible. However, accessibility and the time element involved were also taken into consideration when making the selection of these points.

Samples have now been collected at these same locations for a period of more than four years. Collections are made at monthly intervals throughout the year and samples are generally taken on days when flow and run-off are normal. This practice cannot always be followed, as there are periods when precipitation is long-lasting, but for the most part true samples are collected. These samples are compared in our laboratory on the basis of the standard cobalt scale. As you know, the Public Health Service standards recommend a color of delivered water not to exceed 20 ppm. However, it is thought that complaints will not be registered in any numbers until the color reaches 30 ppm.

Our records on this color survey show that the streams have the same general characteristics year after year, so that the results are now quite conclusive.

After studying the conclusions drawn, the use of certain storage and collection reservoirs has been so regulated that the best water is always made available to the public. We have also undertaken the removal of brush and debris along the streams. We hope soon to inaugurate a winter program of ditching the streams that exhibit high color characteristics. We are now adding alum at the upper end of one small collection reservoir, strictly on an experimental basis. It is too short a time to evaluate what effect it has had on reducing color but the results to date look promising.

During the past years there has been a very substantial improvement in the color of the water on all supplies and this trend will continue as long as the supplies are carefully supervised and maintained. The water we now deliver to the public is quite satisfactory and complaints during the past few years have been extremely few.

We honestly believe that Bridgeport Hydraulic Co. tries its best

to supply good water and, at the same time, keep in touch with modern-day methods and improvements.

Discussion

E. Sherman Chase (Boston, Mass.). It is interesting that Professor Morris' paper preceded Mr. Silliman's paper, because in Mr. Silliman's paper is perhaps the answer to how to prevent contamination of our water supplies with radioactive substances; namely, to follow the good old New England custom of going to relatively unpolluted watersheds and then maintaining those watersheds in a cleanly condition, rather than doing as Philadelphia is continuing to do, using the polluted Schuylkill and Delaware Rivers; to follow the New England precept that innocence is better than repentance.

William W. Brush (New York, N. Y.). I would like to ask Mr. Silliman if there has ever been any court action necessary in any case to stop pollution or reduce it.

Frederick B. Silliman. We have had no difficulty so far and have had no court cases since I have been there, which of course is not too many years. We do not expect to get away with that very long, however, and once in a while we do run into, you might say, a tough nut. We have one right now as a matter of fact. I think he is a doctor.

Peter C. Karalekas (Springfield, Mass.). Do you have any concentrated areas of population within your watersheds—that is, small towns?

Mr. Silliman. We have no areas which are very densely populated. There are very small towns but nothing that will cause any great deal of trouble.

Mr. Karalekas. The other question I had was this: Do you inspect all communities in your watershed area?

Mr. Silliman. We inspect every one that could possibly contaminate the supply. We try to look at them at least once to make sure of them.

Donald C. Calderwood (Nashua, N. H.). I am wondering where, as a private company, they get all the money to do this. All of these things seem very fine. Of course, eventually either the thing must be self-supporting, as far as your timber operations are con-

cerned, or it has to come out of the rate payer. I was wondering where the money came from and what the average home would have to pay for an annual water rate.

MR. SILLIMAN. We have not had to increase our water rate since, I believe, 1926. The thing that is mainly carrying us now is the fact that the consumption of water is greater than it was in past years. We are still paying our usual dividend of 4% and certainly hope to continue.

MR. CALDERWOOD. What is the average water rate for the average home—the water bill?

MR. SILLIMAN. With one bathroom the rate is about $16 a year. That is a fixture charge, which includes a wash-basin, a kitchen sink and one bathroom. That is for a complete plumbing system.

MR. BRUSH. Have you found it necessary to use company land to take care of the sewage from many of the homes on the watershed or is that generally taken care of by the surrounding land owned by the owner of the house?

MR. SILLIMAN. To the best of my knowledge we have put someone else's sewage on our land only once. We try to take care of it on their own land.

RANNEY WATER COLLECTORS IN NEW ENGLAND

BY JORDAN S. ASKETH*

[*Read September 17, 1947.*]

One efficient method of abstracting water from the ground is through the installation of subterranean galleries, intercepting the flow of ground water. The principle involved is old and has been used by the Romans. A good example is the Hadrian aqueduct, tapping underground water-bearing strata by means of subsidiary galleries, which is still functioning in Athens, Greece, although it was built under Emperor Hadrian, 134 to 140 A.D.

Ranney collectors employ the same principle but in a more efficient fashion, modern engineering tools and materials being used to accomplish better results more economically. A Ranney collector is actually a well with horizontal screen, the length of which is not limited by the thickness of the formation but can be varied at will. Briefly, it consists of a main shaft, sealed at the bottom, with lateral screen lines collecting the water. The shaft is a cylindrical reinforced-concrete caisson, sunk in the ground by the open excavation method, concrete sections being added at the top as the caisson sinks in the ground. Sealing of the caisson at the bottom is accomplished by concrete, placed under water, and a relatively tight construction is obtained by the provision inside the caisson of an annular recess near the cutting shoe. The screen pipe is jacked out horizontally through precast port-holes in eight-foot sections, welded together, and individual screen lines have, as an average, lengths of 100 to 150 ft, although many lines projected have exceeded 250 ft and one has reached a length of 320 ft. The length of a screen line depends largely on the possibilities of encountering an insurmountable obstruction at the digging head, such as one large boulder or a group of smaller boulders.

By virtue of its construction, a Ranney collector is equivalent to a vertical well having a very large diameter, usually 200-300 ft,

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with a horizontal screen normally located at the very bottom of the water-bearing formations, this construction enabling the utilization of all the available head in the aquifer. It is obvious from the foregoing that the screen is of necessity covered by water and is thus protected from the undesirable effects of alternate exposure to air, which, it is believed, is largely responsible for the incrustation of well-screens. Horizontal screens can be projected in sand-gravel formations, as shallow as ten feet in depth, to a designed total screen length determined by approach velocity requirements to prevent screen clogging. A graduated gravel cushion around the screen is developed through the utilization of the natural full hydrostatic head on each screen pipe individually and through the removal of "fines" from the space around the screen. During this construction stage, water velocities are several times higher than under normal operating conditions and the removal of "fines" is so complete that practically no sand entrainment occurs during the life of the structure.

Ranney collectors can be installed in all types of water-bearing formations and, normally, economically exploitable depths are limited to 200 ft below ground. Ranney installations are especially suited for the production of naturally purified water through induced infiltration of surface water from rivers, lakes or ponds, provided the water-bearing formations extend up to the surface and both ground- and surface-water bodies are in mutual contact.

New England, which was periodically invaded by the continental ice sheet and possesses a plurality of locations covered by glacial outwash deposits, and where streams, lakes and ponds of glacial or other formation abound, is especially adapted to the abstraction of ground water through the application of the Ranney system. The constant demand for more water by innumerable forward-looking communities and the great industries of New England will, no doubt, help to introduce the Ranney collector on a reasonably large scale in New England and to make its merits appreciated more fully by the many. The field is still comparatively virgin but a considerable amount of preliminary work is now in progress.

Although there are more than 60 successful units all over the United States, only two have been installed in New England, both in Connecticut—one for the American Cyanamid Co. in Wallingford and

the second for the Hartford Rayon Corp. in Rocky Hill. The first unit was tested quite comprehensively and found to be good for approximately 5 mgd, while the capacity of the second, installed about 50 ft out in the Connecticut River bed, is conservatively estimated at 10 mgd. Recent tests in the latter revealed that, for a capacity of 2.5 mgd, the drawdown was only 18 in. Both installations are very successful and obtain water through induced infiltration from surface streams.

The Wallingford unit has been in continuous operation for the past two years and its main characteristics are: depth below river bed to horizontal screen—66 ft; total horizontal screen—1,002 ft, all projected under the Quinnipiac River; number of screen lines—6, with a maximum length of 201 ft and a minimum length of 136 ft. The Rocky Hill unit has two tiers of screen, one 26 ft and the other 42 ft below the river bed. The upper tier of screen pipes, with a total of 786 lineal feet, taps water-bearing formations in direct contact with the river, while the lower tier, with a total of 37 lineal feet, taps water of a lower horizon, also in contact with the river but from a distance, due to the interposition of a clay lens. Since there was a need for both cool and relatively warm water, the lower tier of screen pipes was isolated, to obtain a small capacity of cool water in summer. A much larger capacity of warmer water is obtained from the upper tier. The installation has just been completed and is now under test, and it is too early to state whether this type of installation will fulfill this added function of double-temperature water abstraction, as anticipated.

The major advantage of the Ranney collector as a tool of groundwater abstraction lies in its ability to obtain water through induced infiltration from rivers or lakes. Some collectors have been installed within the river or lake-bed area, with all screen pipes projected under the river or lake. The water obtained through downward seepage is actually surface water, which, in its flow through the natural filter bed underneath the surface-water body, is subjected to a thorough filtration and partial cooling. Because Ranney collectors are sunk deep in the ground and are supported on solid foundations, they are secure against the danger of undermining through erosion, brought about by floods or severe wave action. The structure is sufficiently heavy and can normally withstand the thrust of flood waters by

gravity alone, without considering its additional strength as a cantilever structural member. The structure is usually extended two or more feet above the maximum flood level, to protect the pumping plant from damage.

Concerning the efficacy of the natural filter bed, which, in the majority of cases, is quite thick—ranging from 15 to 100 ft or more—the water in its path to points of low potential (horizontal screen lines) is forced to flow by gravity through the river bed and the various pervious formations underneath and is relieved of its suspended and colloidal load, including bacteria. The largest part of this load is retained right at the river bed, where it forms a gelatinous layer having high adsorptive qualities. This layer is similar to the one formed on ordinary sand filter beds, with the exception that the horizontal movement of river or lake water is constantly engaged in cleaning the bed and preventing this film from becoming dense and relatively tight. The upper surface layer to an approximate depth of one to two feet or more, is completely renewed through erosion during the winter high-water period and through deposition of fresh material during the period of flood subsidence. This process may be repeated several times annually.

In all cases, to date, water obtained through induced infiltration was fit for immediate consumption and all suspended matter, such as bacteria, colloidal color, taste and odor produced by organisms in suspension were completely removed. Three installations are cited by way of example, where such water was obtained: one on the Ohio River for the Indiana Ordnance Works, consisting of seven units, where water samples were taken and analyzed consistently during the entire plant operation by duPont and Army personnel in charge of the plant; a second installation in Connecticut on the Quinnipiac River for the American Cyanamid Co., and a third for the city of Manitowoc, Wis., on Lake Michigan, where again water samples were taken and analyzed regularly.

In locations where the depth of pervious formations below the river bed is small, it is possible to increase water travel through the formations and thus improve filtration conditions, by placing the collector at a certain distance away from the river. This would, of course, mean a reduction in the collector capacity or, conversely, an

increase in the drawdown, since friction losses in the water-bearing formations would be greater. Locating the collector at a certain distance from the river would also mean a more complete heat exchange between the infiltrating water and the ground, the water having a greater chance to dissipate its heat in summer and to absorb terrestrial heat in winter and thus being granted the benefits both of filtration and conditioning.

For practical purposes, it is safe to say that all suspended mineral constituents, as well as bacteria, algae and other micro-organisms, would be entirely removed by the filter action of the water-bearing formations. On the other hand, any substance that might be in solution in the raw water would likely remain in solution after natural filtration and water obtained from collectors would have the same qualities as the river water, minus the suspended and colloidal matter and live organisms.

The hardness of water obtained from infiltration units is generally low, because the hardness of the original surface water is usually low. Water is likely to become slightly harder in its travel through the pervious formations but the percentage of hardness-increase is usually small.

On the basis of the foregoing, if the river or lake contains iron in solution, the natural filter bed will be incapable of removing said iron but, if the iron is in suspension, it is expected that the water, after flowing through the pervious formations, will be completely relieved of its iron load.

In certain cases where iron-free sand-gravel deposits rest on iron-laden formations, it is possible to obtain iron-free water by projecting the screen clear above the latter formations, inducing direct infiltration from a surface-water body and thus minimizing water circulation within the iron-laden mass. Generally, by locating the screen away from iron-laden formations, it is possible to reduce considerably the disagreeable effect of iron in water.

Ranney collectors are installed only on the basis of an engineering investigation and sub-surface explorations, conducted in the prospective client's territory, to determine the potentialities of the field and the possibilities of a successful Ranney installation. At the completion of the field survey, a report is submitted to the client,

in which all the findings and conclusions are presented for his consideration and further action.

Discussion

R. J. Walsh (Cambridge, Mass.). What size caisson do you put down—standard, or what diameter?

A. Leland Glidden* (New York, N. Y.). The average diameter is 13 ft but we do put down a smaller unit, that has an inside diameter of 11 ft. We have also put down some larger units, which have an inside diameter of 20 ft. Usually, when we have to go down below 150 ft, we use that larger-size unit, as it gives more strength.

Thomas A. Berrigan (Boston, Mass.). Did you find it necessary to cap that shaft and use air to get that shaft down?

Mr. Glidden. No. We put the shaft down by the open-excavation method, by setting the steel forms up on the ground and pouring the concrete, and then, after the concrete sets, we remove the steel form and, with the clamshell bucket, reach in and start taking the stuff out of the middle. When the ring comes down to the ground level again, we set the form back and repeat the process.

Mr. Berrigan. How many stages are there in these pumps—water impellers?

Mr. Glidden. Your regular deep-well pumps—impellers—down at the bottom of the caisson.

Mr. Berrigan. Three or four stages?

Mr. Glidden. Sometimes more than that, depending on the total water head. At one well that was put in at a duPont plant in St. Paul, where the capacity of the well was in excess of 16,000 gal a minute, they did not have enough pumps to put in there to get all of the water.

Mr. Berrigan. Might I inquire on your laterals? Don't you find it necessary to use compressed air?

Mr. Glidden. I am glad you mentioned that, because it is a question that is up right now, as to whether we should use compressed air or not. One school of thought thinks that, if you use compressed air, you are likely to create an air lock, which might prevent water from flowing to your screens. The other school feels

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that the compressed air will help to blow out the sand from the lines and you will be able to push them farther. My own personal opinion is that, if you can get high-pressure water, it would be better to use it and not to take a chance on the air lock.

WILLIAM W. BRUSH (New York, N. Y.). To what extent have you used those wells for recharge wells, where you discharge the water down on this back flow—sort of a backwash for your filter, as it were?

MR. GLIDDEN. The recharge is getting to be more and more important in areas where they have been overpumping the ground, such as Louisville, Ky. A lot of industrial plants have moved in there during the war and they have been taking more water out of the ground than nature can replenish. Therefore, a few years ago the U.S.G.S. asked one of the plants down there, that had a Ranney collector, if they would be willing to use that collector to recharge the ground during the winter, when everybody had plenty of water, in order to build up that area so that, in the summer-time, not only this plant but its neighbors would have more water. They tried that out and a paper was written by one of the U.S.G.S. men down there about it. That worked very successfully.

In that connection, I might mention that there is a job going on right now out at Canton, Ohio, for the city of Canton, where this recharge is used a little bit differently. That is an open water body, that has a pervious formation under it, and just below that there is a clay-like, impervious formation, below which there is a second water-bearing stratum. Water from the upper formation is made to flow into the lower formation through a collector. Then they have another caisson a little distance away. They take the water out of the lower formation. That is a case of recharge. They just take it out with another collector at a distance away, to get the benefit of the water's flowing through the ground and being purified.

DONALD C. CALDERWOOD (Nashua, N. H.). At one point in your talk you mentioned the expense of the installation. Would you care to give us some units of cost, by which we could measure approximately what an installation might cost?

MR. GLIDDEN. I should have qualified that "expensive installation" as compared to the ordinary well. If somebody wanted an awful

lot of water, it could turn out to be very inexpensive. The cost of these collectors so far depends upon how far down you have to go, how many of these devices you have to push out, and the number of pumps and the capacity of pump you put in. I might say this—that the cheapest one that has ever been put in has cost around $30,000 and the most expensive one about $150,000. There is quite a range between $30,000 and $150,000 but it all depends on the circumstances.

LINN H. ENSLOW (New York, N. Y.). Could you qualify the cost a little bit by giving a figure per million gallons of developed water?

MR. GLIDDEN. I do not want to depend on my memory for that and I do not want to be held to this, but I think that one figure I recall was about $10,000 per mil gal.

W. S. FOSTER. I know that the question comes up every now and then about what happens to these laterals. You spoke about some going out 300 ft. Would you care to explain? Some people wonder whether they actually go out in this aquifer or take off. Perhaps you could explain how you know exactly that you are putting it right down the line.

MR. GLIDDEN. We had a lot of fun pushing out those laterals in the beginning. We did not know where they were going ourselves. We finally found out a way to tell where they were going and also a way to control their direction. If the lateral is starting to rise, we can tell from the inside of the caisson, when we are pushing the pipe out. As it goes through the valve, it will start to dip a little and give an indication of its direction. If it starts to go down, it will rise a little. But to prove it, especially if it is going up, we run another pipe out inside of the big screen pipe. There is a 3-inch pipe with closed end and inside of that a 1-inch pipe. Then we hook the 1-inch pipe on the inside of the caisson to a hose, held up beside the caisson, pump water into it and, when it reaches the level where it flows out into the hose pipe, we can tell that is where the level is, so that, if we measure it inside the caisson, we can tell how far up the water has gone. To control that, we have put larger slots in the bottom of the digging head or, in some cases, completely closed off the slots in the top of the digging head, so that, when the pipe is going out, we just draw material from the bottom, not from the top. Thus, if it has a tendency to go up, that helps to overcome it.

PAUL F. HOWARD (Boston, Mass.). I would like to inquire whether they have had any experience with these strainers, particularly with reference to installing them above an iron-bearing stratum, where it is iron in solution. The reason I ask that is that, in the late '80s in New England, they built a good many infiltration galleries and had that trouble. Also I know on the West Coast they have had a good deal of trouble. We have had some here in New England, particularly where the gravel well is located above such a stratum, where there is water containing iron. If so, what would you do to overcome it?

MR. GLIDDEN. Did those gravel wells that you mention have a surface-water body above them?

MR. HOWARD. By surface water do you mean a pond?

MR. GLIDDEN. Or a stream in contact with the formation.

MR. HOWARD. No.

MR. GLIDDEN. That was my point in the paper—that, by having these pipes above the iron-laden mass, you have water that has no iron above you and you induce the filtration down from above without making any disturbance of the iron that is below it. One place where they had an actual experience with that is the Pittsburgh Plate Glass Co. at Crystal City, Mo., and the chief chemist wrote a paper, which was published in *Public Works* about a year ago, in which he explained just what happened there and claimed that this installation overcame it. That is the only instance I think of where they proved that it actually happened. But it stands to reason that, if the water above you is feeding the ground in that area through induced filtration and you are not disturbing that iron-laden formation below you, you are not going to have iron in your water. You will have water that has the characteristics of the surface water, for that is your source.

MR. HOWARD. We have had some cases—I have one in mind—where we had that situation. The water-bearing strata above had iron of 0.36 ppm and then there was a stratum of much thinner material, but water-bearing, and, as you got down into that—I don't remember exactly—but the iron went up to 2 or 3 ppm. The installation was successful in the beginning but, over a period of years, the iron content has gradually increased.

MR. GLIDDEN. I remember your paper on that. As I recall, you mentioned something about the effects, the low velocities having beneficially resulted in drawing less iron. That is what I think is one of the reasons why our units draw less iron, because of the very low velocities which are created. It is a case of taking a little water in a lot of directions but, when you bring it together into the central caisson, you have a lot of water.

MR. BERRIGAN. How many laterals do you generally have from your main shaft and what is their ordinary diameter?

MR. GLIDDEN. The diameter of the lateral that we push out has generally been 8 in. Sometimes we have as many as 8, 10 or 14, right around.

FRANCIS H. KINGSBURY (Boston, Mass.). May I ask, what is your oldest installation?

MR. GLIDDEN. The first installation that was ever put in was put in for the Metropolitan Water Board, London, England, for one of their outlying districts. That was put in in 1935. About that installation, there was a write-up in the *Engineering News-Record*. It was interesting there particularly because there was not any rock. It was chalk that the aquifer rested on and above the chalk was about 4-6 ft of sand and gravel. That was all there was. Pipes were pushed out beneath that, right on top of the chalk. It was hoped at that time that the capacity of the unit would be about 2,000,000 imperial gallons and, when they tested it out, it proved to be about 1,850,000 imperial gallons. During the war we wrote the Metropolitan Water Board to find out how that installation was going after all those years, and they wrote back and said, "We will let you know when the war is over." They wrote us when the war was over and said that the capacity was still the same as it was when put in in 1935. That is the oldest one that we have.

MR. KINGSBURY. I should think in that case you would have a relatively noncorrosive water. Have you any installations in this country that have been in corrosive water?

MR. GLIDDEN. Down in New Jersey some of them are but we try to locate these wells in a place where the water is as good as we can find, just for that purpose. Naturally, everybody wants as good water as they can get, so that, when the tests are made, we put them in the spot where the water analyzes the best.

MR. KINGSBURY. The purpose of my question was to gain some information as to whether or not replacement would be necessary after, we will say, 15, 20, 25, 30 or whatever number of years.

MR. GLIDDEN. I guess we are going to have to wait until we have had enough experience on that to tell definitely but I should say offhand that pipes that are covered with water all the time would last longer than pipes that are alternately exposed to the air, which is the case with ordinary well screens. With the collector pipes they are always under water, so that I should think they would last longer. And the thickness of the pipes is three-eighths to a half inch, so that that is another indication that they might last a long time, because they are thicker than the ordinary screens.

MR. KINGSBURY. Are these collectors approved for drinking and culinary purposes or approved only for other purposes?

MR. GLIDDEN. These wells have been used for municipal use as well as industrial use. The city of Manitowoc has one and a number of communities in the central states and down South are using them. However, you are right. Mostly so far they have been used for industrial purposes, but they are being used for municipal purposes right now and we hope that they will be more and more.

MR. KINGSBURY. Untreated?

MR. GLIDDEN. Untreated. Most states require chlorination, regardless of what the water is—whether it shows pollution or not. They require the cities to have the water chlorinated.

MR. KINGSBURY. I just have in mind a request that we had recently, where they wanted to spend $1500 and wanted to run a water pipe underneath the sewer beds. The original plan was for the water pipe to go around, which we approved, and then they wanted to run the water pipe under the sewer beds. They were taking a chance. Of course it would be remote. Nevertheless, something tells me not to take a chance.

MR. GLIDDEN. That is your job.

MR. KINGSBURY. That is why I say that I feel, and I believe that the water-works men here ought to feel, that in all probability the public-health officials would not approve something of that type in New England, where water is taken from a polluted body, but that is no reason why it should not work on the dry land, a reasonable distance from that water.

MR. GLIDDEN. I would say that the proof of the pudding is in the eating—that these wells have been used successfully in other states and by other communities and have saved the cities and towns considerable amounts of money, and eventually New England will do the same thing.

MR. KINGSBURY. Not necessarily.

ARTHUR L. SHAW (Boston, Mass.). I wonder what difference Mr. Kingsbury sees between that and drawing water from 40, 50 or 60 ft beneath the Charles River and pumping the Charles River water over into recharging basins and using the water in the city of Newton.

MR. KINGSBURY. Perhaps I am a little old-fashioned but I am not going to put a well in a cesspool.

MR. GLIDDEN. You would rather take the water directly from the cesspool?

MR. KINGSBURY. I don't think that is quite a fair remark. But I might say that in Massachusetts we only have one water supply that is taken from a polluted stream.

PRESIDENT SHAW. To clarify this situation, let me ask Mr. Glidden: In most of the cases where you hope to draw water from the surface sources, you do not sink the shaft in the bed of the river but on the bank?

MR. GLIDDEN. Yes.

PRESIDENT SHAW. That to some extent limits the chance for pollution by the travel of the surface water down along the shaft and thence into the collectors.

MR. KINGSBURY. We have seen pictures where it has been done but that, I understand, was an industrial plant.

MR. GLIDDEN. Yes, but one of those, I think you will notice, was not in the river but up on the bank, away from the river. Of course you get less water by getting away from the river but you get more filtration.

MR. KINGSBURY. There is the point. I don't know whether that is true. We have, right up here at Lowell, a well right beside the river and the temperature measurements indicate that there is ground water on the way to the river valley. The only time it has been argued that they did get any appreciable amount of river water was when we had the flood of 1936, when we got mud. The mud acts just like

so many little drops of sand. We are getting water that is on its way to a second river that is under the bed of the stream.

MR. GLIDDEN. Has there been any investigation to find out whether the water that you are getting in the well comes from the river, or does it come from the ground water?

MR. KINGSBURY. It comes from the ground water, on its way to the river, in the gravel that is below the bottom of the river, the mud-covered bottom of the stream.

MR. GLIDDEN. You assume, then, that you are pumping ground water?

MR. KINGSBURY. That is right.

MR. GLIDDEN. That has nothing to do with the infiltrating unit, about which I have been talking.

MR. BRUSH. I don't think you explained to us really just what type of screen you use. As I recall, you did not say just how you made that screen.

MR. GLIDDEN. The screen is made by taking flat steel, punching slots in this steel, and then rolling it and welding it into lengths. They are 8 ft long. The size of the openings can be varied but usually the size of each slot has been, in most cases, ⅜ths wide by 1¼ in. long, and that usually gives enough of an opening. About 18% of the total surface area of the pipe is open.

MR. BRUSH. What pressure do you find necessary in the jacking to get these screens out? Do they go out apparently in proportion to the length of the screen and the amount of the pressure on the jacks that is required?

MR. GLIDDEN. Yes. The hydraulic jacks that we use are 100-ton jacks. We watch in pushing the pipe out and will not let it get above what we consider a safe amount of pressure, so as to buckle the pipe. If we can't get a pipe out at that pressure, we stop pushing that pipe and then start with another one.

MR. BRUSH. Is that one jack?

MR. GLIDDEN. Two jacks.

MR. BRUSH. Two 50-ton jacks?

MR. GLIDDEN. No, 100-ton jacks.

PRESIDENT SHAW. Mr. Kingsbury has touched on one subject that I expected a good deal of discussion about—namely, the interest-

ing theory that Mr. Glidden outlined, of the alternate cleaning and fouling of the beds of these bodies of water, which are the source of the surface supplies. My experience has been that most bodies of water are very well sealed in their beds, except in some cataclysmic affair like a flood. I wonder whether Mr. Glidden has made any observations to see whether he does get adequate cleaning periodically of the beds of the bodies of water from which the percolation takes place.

MR. GLIDDEN. That particular point has been covered pretty thoroughly in a paper just recently read by a former U.S.G.S. engineer by the name of Kazmann and the paper was in the June *Proceedings* of the American Society of Civil Engineers. He covers that pretty thoroughly in his investigation of the seven units which were put in for the duPont Co. along the Ohio River. His studies indicated that, after each flood or freshet, the beds had been scoured out and then, after the water level of the river dropped, the material started to build up in the bottom.

PRESIDENT SHAW. I suppose that varies greatly with the nature of the soil and the subsoil, does it not?

MR. GLIDDEN. And the impurities in the river bed.

MR. HOWARD. In the talk between Mr. Glidden and Mr. Kingsbury, Mr. Glidden made a remark about the ground water being higher than the level in the river. I should think that would be possible, if you are far enough back so that you get sufficient hydraulic gradient in the wells above the river level. Wouldn't that be the condition you have to get?

MR. GLIDDEN. We try to get induced filtration, because, if we are only going to rely on the ground to supply us, we may not have enough water.

MR. HOWARD. Therefore you are purposely trying to get that infiltration from the river?

MR. GLIDDEN. That is right.

MR. HOWARD. It just boils down to whether that filter is adequate and can be relied on.

MR. GLIDDEN. Yes. It is no longer what you mean by opinion or beliefs about it. It is actually being done.

MR. ENSLOW. It appeared from the studies at Louisville, Ky.,

that the water they were drawing down there came from six miles above Louisville, or at least some of it. Instead of that water coming more or less quickly from the river directly, or within a short distance, they had some proof there that it had actually traveled parallel with the river for six miles.

MR. GLIDDEN. There was a clay barrier that, to some extent, shut the river off from direct flow to the well at the point where the well was located. But they did get some from the river there and some not only from upstream but downstream. That is an interesting point, because it did help the filters by making most of the water travel farther.

MR. ENSLOW. Just one more question. Out in West Virginia—it is not Clarksburg but I can't remember the name of the town on the Ohio . .

MR. GLIDDEN. Parkersburg?

MR. ENSLOW. Parkersburg. They for years had a collection gallery parallelling the river. I understand now they have a Ranney collector. Why would not the collection gallery work there if the Ranney collector would work?

MR. GLIDDEN. There was a paper written about that in *Water Works Engineering*—I think April. But they did not have collection galleries; they had vertical wells. The paper that I speak of said that they had 28 vertical wells—barrel-type wells—and they had to put a new one in every once-in-a-while, because it sanded up, and to overcome that they put in the collector. But I don't remember reading anything about a collection gallery which they had there. That is news to me, about the collection gallery.

MR. FOSTER. When I was out in Wisconsin a couple of years ago, some of the members of the State Board of Health out in the state of Wisconsin did point out this Manitowoc installation as a very interesting and very well-operating system. Of course, it is always unwise to generalize but at least there was no fear on the part of those gentlemen, and my observation has been that the state of Wisconsin has some rather capable sanitary engineers. But that particular installation, I believe, was out of the lake.

MR. GLIDDEN. Yes, sir. I might say that a number of our

installations have been ground-water installations. The biggest one was for the Timken Roller Bearing Co. There is no river within about two miles of where this unit was installed. That is a rather old unit; it was put in in 1936. That is purely a ground-water unit, not near a river, lake, stream or anything. It still has a capacity in excess of 6,000 gal per min. But most of our units have been along rivers or streams.

MEMOIR OF
JAMES L. TIGHE

James Laurence Tighe, nationally recognized authority in the field of sanitary and hydraulic engineering, died in Holyoke in his eighty-third year on April 6, 1947. Born in 1864 on a farm near the village of Virginia in County Cavan, Ireland, he attended public and private schools in his native district, coming to this country at the age of twenty-three. Mr. Tighe attended McGill University in Montreal, studying civil and hydraulic engineering, and graduated in 1892 with the degree of bachelor of applied science. During summer vacations from McGill, he obtained valuable engineering experience while working under J. Waldo Smith, later Chief Engineer of the Catskill water development for New York City, and under Clemens Herschel, another noted hydraulic engineer.

Mr. Tighe served as engineer of the Holyoke Water Department from 1892 to 1911 and also as City Engineer from 1899 to 1911. The present water-supply system of Holyoke is the result of his careful planning and vision, and he is often referred to as the "father" of the Holyoke water system. Mr. Tighe entered private practice as a consulting engineer after service with the city, later taking into his office Philip E. Bond, former City Engineer, and, under the firm name of Tighe & Bond, developed a wide practice in the planning, construction and improvement of municipal and private water and sewerage systems. Since 1900 Mr. Tighe had served as Consulting Engineer to the Hampden County Commissioners and since 1923 he had been a member of the Holyoke Gas and Electric Commission, having served as its Chairman since 1928.

Mr. Tighe devoted many years to the service of the Commonwealth, having been a member of the Massachusetts Public Health Council since 1923 under seven Governors. His last appointment for a six-year term was made by Governor Saltonstall in 1941. This record of appointment and re-appointment was a recognition by the

Commonwealth of his valued services and a record probably rarely exceeded by any public servant.

Throughout his career, Mr. Tighe was a noted expert in the preparation and presentation of evidence in court cases involving sanitary and hydraulic engineering throughout New England and the middle Atlantic states.

His professional associations included membership in the American Institute of Consulting Engineers, the American Society of Civil Engineers, the Institution of Civil Engineers of Great Britain, the Engineering Institute of Canada, the Boston Society of Civil Engineers, the American Water Works Association, of which he was an honorary member, and the American Public Health Association. He became a member of the New England Water Works Association on March 9, 1898.

Mr. Tighe was an experienced traveler and practically every year for a generation, until World War II, he visited his native Ireland, where he maintained an estate a short distance from the family home in County Cavan.

James Tighe was a man who bore with modest dignity the public honor and private respect that came to him as the natural rewards of a long life of service to his community and fellow men.

ARTHUR D. WESTON

MEMOIR OF
FRANK A. BARBOUR

Frank Alexander Barbour was born in Saint John, New Brunswick, May 5, 1869, and died suddenly May 24, 1947, on a private golf course near his home in Framingham Center, Mass.

Mr. Barbour graduated from the University of New Brunswick in 1888 with an A.B. degree. He was at first engaged in railroad survey and construction work in Canada but came to Boston after a few years, where he did railroad location work in New England. After an engagement on the Sudbury water supply for the city of Boston, he was connected with the city of Brockton, Mass., on the development of the water and sewerage works. There he met F. H. Snow, with whom he was later associated in private practice in Boston until 1905.

The office, established in 1898, was maintained at the same location by Mr. Barbour until his death. He specialized in municipal sanitary engineering, particularly water-supply, sewerage and sewage-treatment works. He designed and supervised construction of water works and sewerage in the Middle West, at the turn of the century, and one of his outstanding accomplishments, begun in 1910, was the design and construction of supply works, filtration plant, transmission mains and distribution system for the city of Akron, Ohio. His work on appraisals and valuations of water systems was quite extensive in later years.

Mr. Barbour was the first of the supervising engineers selected by the War Department, when the 16 cantonments for the National Army were required in World War I, and through his energetic leadership Camp Devens, Mass., was constructed in three months to house 35,000 troops—an outstanding performance for that time. In World War II Mr. Barbour was again called upon and, at 70 years of age, repeated his 1917 service in the expansion of Fort Devens.

Frank Barbour was not only an engineer of exceptional ability and unquestioned integrity, but he was courageous in carrying through

his well-developed plans, even though in conflict with precedents. It has been well said that he had a "dynamic and forthright personality".

He was active in professional society work, having been a member of the New England Water Works Association since 1894, its President in 1922 and an honorary member since 1934. He was Past President and honorary member of the American Water Works Association, Past President of the Boston Society of Civil Engineers, life member and past director of the American Society of Civil Engineers, and the author of numerous technical articles.

He was a Mason and a member of the Boston Engineers Club, as well as a member and Past President of the Framingham Country Club. He is survived by Mrs. Barbour, the former Dorothy Boswell of Philadelphia.

As a contemporary, practicing in nearly similar work, and an associate on many committees and in society activities, I want to record my appreciation of his ability, his fairness and his many services to the profession, and my deep sense of personal loss in his passing.

CHARLES W. SHERMAN

PROCEEDINGS

Sixty-sixth Annual Meeting

Boston, Mass.

September 16 to 19, 1947

The Sixty-sixth Annual Meeting of the New England Water Works Association was held at the Hotel Statler, Boston, Mass., on September 16 to 19, 1947.

Tuesday, September 16

Morning Session

President Arthur L. Shaw presiding.

The Annual Reports of the Secretary, Treasurer, Editor, Committee on Library, Committee on Membership, Finance Committee, Committee on Legislation, Committee on Committees and Committee on Reciprocal Relations with the Institution of Water Engineers (England) were presented and accepted.

The following progress reports of technical committees were presented and accepted: Committee on Gate Valves, Hydrant Specification Committee, Committee on Laying Cast-Iron Pipe, Committee on Specifications for Cast-Iron Pipe and Fittings and Committee on Meter Specifications.

An informal report was presented by the Committee on Threads for Underground Service Line Fittings. All formal reports are printed in this issue of the Journal.

The President declared the polls closed and appointed as tellers Roger G. Oakman, Sydney C. Beane and G. Arthur Faneuf.

There was considerable discussion in regard to the Executive Committee's decision not to publish a paper, entitled "Contractor's Problems in Construction of Water Distribution Systems," which had been presented by Eugene M. Reppucci at the March, 1947, meeting of the Association. Upon motion of Roger W. Esty, duly seconded,

it was unanimously VOTED that the Executive Committee be requested to reconsider the matter—the publication of the Reppucci paper—with a view to publication of the paper in its entirety.

Secretary Knox announced the election of the following to membership in the Association:

Gordon A. Barker, Supt., Dennis Water District, South Dennis, Mass.; John T. Barnhill, Chemist, Metcalf and Eddy, Boston, Mass.; Harold W. Blake, Engineer, Thomas Worcester, Inc., Boston, Mass.; William M. Burns, Asst. Supt. of Public Works, Lexington, Mass.; Eugene R. Davis, Engineer, Metcalf and Eddy, Boston, Mass.; Terrance J. Durant, Supt., Shirley Water District, Shirley, Mass.; Carl A. Ellis, Hydraulic Engr., Associated Factory Mutual Fire Insurance Cos., Boston, Mass.; Edward A. Farmer, Cons. Engr., Black & Veatch, Kansas City, Mo.; Edward A. Graustein, Hydr. Engr., Thomas Worcester, Inc., Boston, Mass.; John H. Harding, Cons. Engr., Hayden, Harding & Buchanan, Boston, Mass.; Stephen Haseltine, Engr., Metcalf and Eddy, Boston, Mass.; J. Wilbur Irish, Cons. Engr., Peekskill, N. Y.; Malcolm G. Keniston, Supt., Edgartown Water Co., Edgartown, Mass.; Henry A. Kingsbury, Engr., Metcalf and Eddy, Boston, Mass.; John P. Lynch, Technician, Water Dept., Springfield, Mass.; Ira P. MacNab, Mgr., Halifax Public Service Comm., Halifax, Nova Scotia; Regina L. Martineau, Moore & Co., Boston, Mass.; William H. McGuinness, Supt. (Acting), Water Dept., Cambridge, Mass.; Robert W. Muther, Jr., Junior Engineer, Metcalf and Eddy, Boston, Mass.; Edgar F. Orpin, Manager, Wannacomet Water Co., Nantucket, Mass.; Mohammad Abdur Rehman, Metcalf and Eddy, Boston, Mass.; Lincoln W. Ryder, Engr., Metcalf and Eddy, Boston, Mass.; Frederick B. Silliman, Engr., Bridgeport Hydraulic Co., Bridgeport, Conn.; John R. Snell, Engr., China San. Engr. Serv., Inc., Melrose, Mass.; E. Warren Ward, Partner, Haley & Ward, Boston, Mass.; William L. Wenzel, Supt., Water Dept., Wakefield, Mass.; George A. Wescott, Meter Supt., Portland, Me.; Clarence Wickerson, Cons. Engr., Winchester, Mass.

Reinstated: Ivan A. Buchanan, Engr., Burns & Kenerson, Boston, Mass.; Frederick A. Cole, Engr., Moore & Co., Boston, Mass.

Associate: Albert Pipe Supply Co., Inc., Brooklyn, N. Y.; Ozone Processes Div., The Welsbach Corp., Philadelphia, Pa.; Andres Rozlosnik, Buenos Aires, Argentina.

Luncheon Session

Award of the Dexter Brackett Memorial Medal

President Shaw. The first matter which is on the program of this afternoon's session is the award of the Dexter Brackett Memorial Medal. It has been my observation in past years that the presiding officer has frequently attempted to outline the origin and purpose of this medal and, in so doing, he has rather stolen the thunder of the member who has been delegated to make the presentation; so that I think without further ado I shall ask Past-President E. Sherman Chase, who is the chairman of the Award Committee, to make the presentation of the Dexter Brackett Medal. Mr. Chase.

E. Sherman Chase. Mr. President, ladies and gentlemen:

In view of the fact that it has been customary for the presiding officer to outline the history of the Dexter Brackett Memorial Award and to expound the reasons for its award, on this particular occasion, as chairman of the committee this year, I failed to prepare any such exposition; so that I feel a bit let down and must more or less extemporize as I go along.

Not remembering the details of Dexter Brackett's life, I can only say that Dexter Brackett was one of the early members of this association, that he was very, very practical in his affairs and was held in the highest regard by his contemporaries. Following his death many of the members desired that his memory be perpetuated by this particular form of award and a substantial sum was raised, approximately 35 years ago, to finance the design and preparation of bronze medals for each successive year.

These medals are awarded on the basis of four rules, laid down by a committee established in 1916. These rules are substantially as follows: First, the award goes to a member of the association—only members are eligible; second, the paper must be published in the Journal for the year of the award; third, the paper must be substantially original and shall not have been previously published; fourth, the paper shall be particularly meritorious and applicable to waterworks practice.

The present paper, for which the award is being given, was published in the December issue of the Journal last year. It is entitled

"Problems in Disposal of Sludge and Wash Water for Connecticut Water Filtration Plants." This sounds like a rather specialized sort of paper but it is a fact that there is no other paper that I know of—or that the committee knows of—of a similar nature or that gives the particular kind of data that this paper contains. I am sure that none of the JOURNALS of the Association has ever published a paper of this character. In other words, it is perhaps absolutely unique in that it gives data and information which, so far as I know, are not available elsewhere.

The recipient of this award is the principal sanitary engineer of the State Department of Health of Connecticut. He is a graduate of the M.I.T. course in sanitary engineering of the year 1923. For some three years he was assistant chemist at the Little Falls water-filtration plant of the Passaic Consolidated Water Co. That Little Falls plant, as many of you will remember, was one of the pioneer filter plants of this country. Since 1926 the recipient has been a member of the engineering staff of the State Health Department of Connecticut and, at the present time, as I said before, is principal sanitary engineer.

It therefore gives me great pleasure and honor to present to Mr. Frederick O. A. Almquist of Connecticut this bronze medal, in commemoration of one of our outstanding members of the past—Dexter Brackett. Mr. Almquist.

FREDERICK O. A. ALMQUIST. Mr. Chairman, Mr. President, members and guests of the Association:

I suppose that in a man's life there are many times when he is tempted to say, "This is the happiest moment." I can safely say, however, that this is one of the happiest moments of my life.

In writing the paper, my only thought was that the experience gained in Connecticut might be of some help to others in the water-works fraternity and, if it has been of some help, that is sufficient satisfaction for writing the paper and is a sufficient reward. To receive an additional award, such as this, on top of it gives me that much more personal satisfaction. I know I shall cherish it the rest of my life and I wish to thank the committee.

Incidentally, Mr. President, I think the committee did a grand job—I personally think that they did a wonderful job!

Afternoon Session

A paper on "The Dynamics of Water Chlorination," prepared by Gordon M. Fair, J. Carrell Morris and Shih Lu Chang, Department of Sanitary Engineering, Graduate School of Engineering and School of Public Health, Harvard University, Cambridge, Mass., was read by Dr. Chang.

A paper on "Contamination of Water Supplies by Radioactive Substances", prepared by J. Carrell Morris and Jeanne B. Carritt, Department of Sanitary Engineering, Graduate School of Engineering, Harvard University, Cambridge, Mass., was read by Prof. Morris.

A paper on "Watershed Practices of Bridgeport Hydraulic Company, with Particular Reference to Aerial Watershed Surveys" was read by Frederick B. Silliman, Civil Engineer, Bridgeport Hydraulic Co., Bridgeport, Conn.

Evening

Through the courtesy of the Water and Sewage Works Manufacturers Association, Inc., an entertainment was given in the ballroom of the hotel.

Wednesday, September 17

Morning Session

A paper on "Ranney Water Collectors in New England", prepared by Jordan S. Asketh, Chief Engineer, Ranney Water Collector Corp. of New York, New York, N. Y., was read by A. Leland Glidden.

A paper on "Economics of Rehabilitation of 3-inch to 24-inch Water Mains" was read by Alfred B. Anderson, Chief Engineer, Water and Sewer Division, Pittsburgh Pipe Cleaner Co., Pittsburgh, Pa.

An all-color moving picture, "New England Calling," was shown through the courtesy of the Colonial Beacon Oil Co., Boston, Mass.

A moving picture, "Watts in Glass," by the Owens-Corning Fiberglas Corp., Toledo, Ohio, was shown.

Evening

A dance was held in the ballroom of the hotel, through the courtesy of the Water and Sewage Works Manufacturers Association, Inc.

Thursday, September 18

Morning Session

A paper on "Releases from Quabbin Reservoir Used to Develop Power" was read by Chester J. Ginder, Senior Civil Engineer, Construction Division, Metropolitan District Commission, Boston, Mass.

A paper on "Ground-Water Conditions in the Vicinity of Mashapaug Pond, Providence, R. I.," prepared by R. M. Jeffords and W. B. Allen, U. S. Geological Survey, Providence, R. I., was read by Mr. Allen.

A moving picture on "Ground-Water Development" was shown by Alan W. Ross, Vice-President, Layne-New York Co., Inc., New York, N. Y.

Afternoon Session

Secretary Knox announced the election of the following new members:

Fred E. Colby, Supt., Water Dept., Bridgewater, Mass.; James L. Dallas, Sanitary Engineer, Beverly, Mass.; Carroll Pritham, Supt., Water District, Presque Isle, Me.

On the subject of "Flood-Control Structures," a paper on "Design" was read by John E. Allen, Chief of Engineering, New England Division, Corps of Engineers, U. S. Army, and a paper on "Construction" was read by Carl H. Lovejoy, Chief of Operations, New England Division, Corps of Engineers, U. S. Army.

A paper on "Emergency Water Supply for Rutland, Vermont, Following Flood of June 3, 1947," was read by Edward L. Tracy, Director, Division of Sanitary Engineering, Department of Public Health, Burlington, Vt.

A paper on "Chlorine Dioxide as a Bactericide in Water-Works Operations", prepared by John F. Synan, Sales Development, and G. P. Vincent, Technical Director, Mathieson Alkali Co., New York, N. Y., was read by R. H. Aston.

Evening

Dinner and dancing were enjoyed by the members and their guests in the ballroom of the hotel, through the courtesy of the Water and Sewage Works Manufacturers' Association, Inc.

Friday, September 19

Morning Session

Superintendents' Round Table

A paper on "Selling Your Water Works" was read by George N. Watson, Superintendent, Water Department, Braintree, Mass.

A talk on "Distribution-Pipe Problems" was given by Kenneth W. Robie, Engineer, Water Department, Brookline, Mass.

Presidential Address

By Arthur L. Shaw

The retiring president of the New England Water Works Association commonly deals with Association affairs in his closing address, outlining the progress made during the year and the prospects for the year ahead. I should like to change the pattern a little and briefly discuss some of the current factors affecting the waterworks industry as a whole.

In common with many lines of business we are still plagued by short supply of many essential items. Pipe and fittings, steel standpipes and tanks, pumps, motors and other electrical equipment, to mention only a few, still require many months for delivery. This means that even the simplest new construction can seldom be finished within a year of its inception. The effect of delays in materials and equipment can be minimized, if waterworks management will take the long view, planning and executing work to meet future requirements well in advance of the actual need. During the war years, hand-to-mouth planning was inescapable. This is no longer necessary.

In a surprisingly large number of municipalities, rates of water consumption have continued at a high level in contradiction to the expectations that, with the end of the war, consumption would fall back to former rates. The cause of this is not wholly clear. The phenomenon appears even in some communities where the activity of great war industries has ceased or greatly diminished. It is probable that in many instances there has been no great shift of population, no pronounced return to former homes by people who moved into centers of war production. In such places the return of ex-service men and

their families has increased the domestic water consumption, at least partly offsetting any reduction in industrial demand.

In some communities falling into this category, the facilities of water systems were stretched to the limit during the war, operating with little or no safety factor in the expectation of relief at the end of the war. Such systems—and there were many—must now undertake new development and construction to meet the continuing large demands with adequate and prudent reserves of source and equipment. Waterworks management is not to blame for this state of affairs but it is management's misfortune that it must struggle to bring its property up to date in these times of shortages, slow deliveries and high prices.

Not the least of the current problems is that of high and still-mounting costs. There is as yet no evidence that lower costs can be expected for a long time. Only two things can bring this about. The first is a senseless continuation of the present ascending spiral of unqualified wage demands and resulting increase in commodity prices, with an inevitable inflationary collapse. The memory of the thirties is still too vivid for anyone to want that.

The second means of lowering prices lies in the education of the rank-and-file of labor in a few basic economic facts. Reduced to the simplest terms these facts are: (1) that under our capitalistic system there are three interests which must be given consideration in any successful business—*viz,* labor, investment and consumer; and (2) that wealth is not truly measured by the wages that are paid but rather by the tangible production that results in return for these wages.

The manager of any business has three major responsibilities—to the labor which produces its output, to the money invested in the business and to the customer who purchases its goods.

No intelligent manager would contend that his business could succeed in the long run without employees who are well paid and who serve under good working conditions. He knows that willing effort and loyalty of labor are necessary parts of any smooth-running enterprise and he recognizes his duty to labor in his plant. But he also knows that he is equally responsible to other factors.

Capital, the money used to build, equip and operate a business,

represents the savings of a broad segment of our people. When this money is put to useful work, the people who own it are entitled to reasonable compensation in the form of interest. If invested money is not reasonably compensated, people with savings will cease to risk them and, without capital, there can be no plants and no jobs for labor. Money should not be asked to work for inadequate hire any more than labor should be underpaid.

The third essential factor is the customer. He is interested in good products, satisfactory service and fair prices. Without consumers there can be no sale of products or service and the business will fail and cease to provide jobs. It is necessary, therefore, for management so to use the capital invested in the business and so to plan the organization and use of labor, that dependable goods at reasonable prices may be produced, while reimbursing both labor and capital at fair rates.

No attempt will be made to discuss in detail the fallacy of the "slow-down", which is a major curse of present labor philosophy. It assumes that wages are the important thing and not production. Carry it to its logical limit and you have the dole, payment of money for doing nothing! Money paid in this way will soon exhaust its supply or become worthless, because no wealth is being created in return for it. Conversely, if honest, diligent work is exerted in return for wages, the latter can advantageously be made generous in proportion to the output of labor.

It is to be hoped that these basic principles can somehow be brought home to labor, which at the moment appears to be carried away with the fact that it currently has the whip-hand. In the meantime, while labor's demands are enforced on management and necessarily passed on in the price of goods and service, new construction will continue to be shockingly expensive and will presumably be limited to that which cannot be postponed.

Many waterworks will be unable fully to keep pace with rising labor rates in dealing with department employees. This is particularly true in the municipal field, where limitations are often beyond the control of immediate management. It is to be hoped that the attraction of assured continuity of employment, together with the fine loyalty that is so often apparent in water departments, will serve to

hold efficient organizations together, until means can be found to equalize wages with those of comparable private industry or until the stabilizing forces of natural economic phenomena have exerted themselves.

I believe that loyalty and pride exist in the waterworks industry to an unusual degree and this is doubtless due in no small measure to the stimulus which always goes with public service. With apologies to Berton Bradley in *Life*, the following verse expresses the attitude of waterworks men toward their calling:

"We don't pose as brave crusaders but we certainly crusade
In an everlasting fight with Mother Earth;
Every dam that we have builded, every pumping station made,
Every pipe that belts the planetary girth,
Is a monument of struggle for the betterment of man.
And we did it, as we do it, and we will,
By the urge of what's inside us, by the spirit of our clan,
And it's something more than money pays the bill!
Though we like our share of treasure and the pleasure that it brings,
It is something else which drives us to our goal;
It's the triumph of our labor over elemental things
And the vision which gives splendor to the whole.
We are members of an order that is guided on by dreams,
We are more than mere artisans or clerks,
And unless you care for Service more than money-getting schemes
You had better never join the Water Works!"

I want to express at this time my very keen appreciation of the loyal work that all the officers and committees of the Association have done during the year and also of the coöperation which the members of the Association have given in their regular attendance at the meetings and participation in its discussions.

This is the closing moment of my administration as president of your association—the moment when I will introduce to you the new president. First, however, I must ask the tellers to report on the result of the election, so that I may know whom to present to you.

Roger W. Oakman submitted the following:

REPORT OF THE TELLERS OF ELECTION

Total vote cast	298
For PRESIDENT: Donald C. Calderwood	293
For VICE-PRESIDENT: Sidney S. Anthony	294
For DIRECTOR: Thomas R. Camp	292
For TREASURER: William P. Melley	295

(*Signed*) ROGER G. OAKMAN, *Chairman*
SYDNEY C. BEANE
G. ARTHUR FANEUF

PRESIDENT SHAW. Your new president has served a long and faithful apprenticeship in the administration of this Association, serving for some time as a director and later as vice-president, and now you have deemed him worthy through that service to be your president.

Don Calderwood, will you step forward and take the chair?

DONALD C. CALDERWOOD. I assure you that it is a distinct honor to be elected president of this, the oldest water-works association in America. I realize that it carries with it certain responsibilities and, in that connection, all I can say is that I will do my best.

At this time I would like to repeat a little comment that our past president made at one of the earlier meetings and that is that each member of any organization gets out of it just what he puts in; the more he puts in the more he can get out. That applies not only to himself but to what he can give to the others. As a parting word along that line, in the closing of this our Sixty-sixth Annual Meeting, I want to ask all of the members to do their bit this coming year and, if they do, I know that the success and the advancement will continue as they have for the years past.

I thank you.

My illustrious coach here suggests that it might be in order at this time to ask if we should adjourn the meeting or if there is some further business that should come before the meeting, before we do adjourn. If there is no further business, will someone make the motion to adjourn?

[A motion to adjourn was duly made and seconded.]

All those in favor of the adjournment of this, our Sixty-sixth Annual Meeting, will signify in the usual manner.

[The motion was carried and the Sixty-sixth Annual Meeting was adjourned at 12:15 p.m.]

ANNUAL REPORT OF THE SECRETARY

Mr. President and Gentlemen of the New England Water Works Association: The Secretary herewith submits the following report of the changes of membership during the past fiscal year and the general condition of the Association.

The present membership is 865, constituted as follows: 10 Honorary Members, 711 Members, 116 Associate Members and 28 Corporate Members.

MEMBERSHIP

				Total
September 1, 1946—Honorary Members, Total		11		
Withdrawals:				
Died		1		10
September 1, 1946—Members, Total		676		
Withdrawals:				
Resigned	16			
Died	14			
Dropped by Executive Committee	1	31	645	
Elected:				
September 16, 1946	11			
October 17, 1946	4			
November 14, 1946	2			
December 19, 1946	2			
January 23, 1947	5			
February 27, 1947	15			
March 20, 1947	12			
April 17, 1947	5			
May 22, 1947	7			
June 11, 1947	2	65		
Transferred from Junior to Member		1	66	711
September 1, 1946—Associates, Total		110		
Withdrawals:				
Resigned		2	108	

Elected:			
September 16, 1946	3		
January 23, 1947	1		
February 27, 1947	1		
March 20, 1947	1		
April 17, 1947	1		
May 22, 1947	1	8	116
September 1, 1946—Corporates, Total	28		
Withdrawals:			
Resigned	1	27	
Elected:			
May 22, 1947		1	28
September 1, 1947—Total Membership			865
September 1, 1946—Total Membership			826
Net Gain			39

ELECTIONS

Members

September 16, 1946—John L. Bean, Francis T. Bergin, Abner C. Bristol, Charles J. Christy, Gerald H. Davis, Walter A. Goss, Richard Hazen, Waldo I. Kenerson, Herbert D. Morrison, Hugo Perez-LaSalvia, Elbert R. Sherman. (11)

October 17, 1946—Arsene Blaquiere, Donald W. Loiselle, Willard P. Sheppard, A. Newton Zahniser. (4)

November 14, 1946—Alice M. Keiran, Stanley W. Turner. (2)

December 19, 1946—George Gardner, Philip B. Streander. (2)

January 23, 1947—William P. Brenchick, James A. Frank, Arthur W. Hoag, Stewart H. Newland, Peter T. Peterson. (5)

February 27, 1947—Gerald W. Blakeley, Albert E. Bragger, Paul J. Cerny, Samuel M. Clarke, Adolph Damiano, John F. Finn, George G. Garrett, Jr., Frank W. Jones, Elliott J. MacNeil, William T. Morrissey, Charles E. Renn, Seymour Squires, Fred A. Stradling, Joseph J. Swiatlowski, Harold E. Willis. (15)

March 20, 1947—Clarence L. Ahlgren, Frederick B. Atherton, Harold H. Bean, Edmund H. Brown, Roger C. Brown, Russell C. Clement, Otis D. Fellows, Henry N. Halberg, John A. McConnell, Jack E. McKee, Frederick E. Thrall, John K. Van Brunt. (12)

April 17, 1947—William J. Almond, Francis E. Butland, Salvatore P. Grasso, John A. Hastings, Wilbur D. Smith. (5)

May 22, 1947—John J. Collins, Jr., Henry A. Galipeau, George E. Keyes, Peter Popielarczyk, Gordon T. Richardson, Thomas W. Speight, Jr., Herman E. Warner. (7)
June 11, 1947—David Fahlstrom, Evart J. Horne. (2)

Associate Members

September 16, 1946—Clayton Manufacturing Company, Pittsburgh Pipe Cleaner Company, H. R. Prescott & Sons. (3)
January 23, 1947—Industrias Espanolas, S. A. (1)
February 27, 1947—Liquid Conditioning Corporation. (1)
March 20, 1947—Engineering Sales Corporation. (1)
April 17, 1947—C. R. Swaney Company. (1)
May 22, 1947—Inertol Company, Inc. (1)

Corporate Members

May 22, 1947—Yarmouth Water Department, Yarmouth, Massachusetts. (1)

WITHDRAWALS

Members

Resigned: Fred R. Ackley, Anthony C. Benjes, H. B. Chandley, James J. Dillon, James E. Fuller, J. Elliott Hale, James P. Joyce, Alfred LaFleur, Theodore J. Lecours, John M. Magee, Hugh McCauley, Alfred H. Osterman, Herbert Scott-Smith, Gordon C. Tower, Charles C. West and David C. Wiggin. (16)
Died: Frank A. Barbour, Peter Bolton, Loren E. Daboll, Fred A. Darling, David D. Eames, Arthur A. Fobes, Clinton Inglee, Harold D. Kilgore, John Knickerbacker, John F. McVey, Jr., Oren E. Parks, Percy R. Sanders, Henry U. Storrs, Frank M. Travis and James L. Tighe. (15)
Dropped by Executive Committee: Justus W. Patterson. (1)

Associates

Resigned: Ashton Valve Company, E. L. LeBaron Foundry Company. (2)

Corporates

Resigned: Portland Water Works, Portland, Connecticut. (1)

RECEIPTS FOR THE FISCAL YEAR SEPTEMBER 1, 1946, TO SEPTEMBER 1, 1947

Entrance Fees		$ 241.00
Dues of All Grades of Members		6,082.50
Dividends		469.27
Advertisements		4,371.38
Subscriptions		645.25
Journals		84.75
Halftones, etc.		6.13
Membership Certificates		49.50
Membership Lists		8.50
Total Receipts		$11,958.28
There is due the Association:		
Dues	$126.00	
Advertising	5.00	131.00
Total		$12,089.28

Respectfully submitted,

(*Signed*) JOSEPH C. KNOX, *Secretary*

ANNUAL REPORT OF THE TREASURER

To William P. Melley, Treasurer,
New England Water Works Association,
Boston, Massachusetts.

We have examined the statement of assets and funds and the statement of cash receipts and disbursements of the general fund of the New England Water Works Association for the fiscal year ended August 31, 1947, have reviewed the accounting procedures of the association and have examined accounting records of the association and other supporting evidence, by methods and to the extent we deemed appropriate.

We traced all recorded receipts into the depositary bank, verified the general fund bank account and petty cash fund as at August 31, 1947, and examined properly approved vouchers for all disbursements. We also verified by direct communication the investment funds on deposit in savings banks, and on September 4, 1947, we examined the United States Treasury Savings Bonds at the Second National Bank of Boston.

In our opinion, the accompanying statement of assets and funds and the note thereon and the related general fund cash statement present fairly the position of the New England Water Works Association at August 31, 1947, and the recorded cash receipts and disbursements for the fiscal year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) SCOVELL, WELLINGTON & COMPANY

STATEMENT OF ASSETS AND FUNDS (EXHIBIT A)
As at August 31, 1947

Assets

Cash in Banks, Invested Funds		
Farmers and Mechanics Savings Bank, Framingham, Massachusetts	$ 1,068.46	
Franklin Savings Bank, Boston, Massachusetts	1,000.00	
Haverhill Savings Bank, Haverhill, Massachusetts	1,000.00	
Home Savings Bank, Boston, Massachusetts	1,000.00	
Mechanics Savings Bank, Reading, Massachusetts	1,000.00	
Pentucket Savings Bank, Haverhill, Massachusetts	1,000.00	
The People's Savings Bank, Worcester, Massachusetts	1,000.00	
Suffolk Savings Bank, Boston, Massachusetts	1,000.00	$ 8,068.46
Securities		
U. S. Treasury Savings Bonds G 2½s, 1954	10,000.00	
25 shares Milton Co-operative Bank, Series of June, 1940	2,495.00	12,495.00
Total Invested Cash and Securities		20,563.46
General Fund		
Cash, Second National Bank of Boston	4,449.85	
In Office	50.00	4,499.85
Total Invested Funds and Cash		25,063.31
Furniture and Fixtures		1,180.00
		$26,243.31

Funds

Invested Funds		$20,563.46
General Fund		
Balance, August 31, 1946	$5,807.22	
Deduct Purchase of Milton Co-operative Bank Shares	300.00	
	5,507.22	

Add Excess of Receipts over Disbursements, Exhibit B	172.63	
Balance, August 31, 1947		5,679.85
		$26,243.31

Note: The statement above, prepared on a cash basis, includes dues received in advance, $2,315, and employees' withholding tax, $46.24. It does not reflect the following:

Accounts Receivable, Dues	$ 126.00
Due on Account of Advertising	5.00
	$ 131.00

No depreciation has been taken on Furniture and Fixtures.

STATEMENT OF CASH RECEIPTS AND DISBURSEMENTS (EXHIBIT B)

General Fund

For the Year ended August 31, 1947

Receipts (exclusive of dues received in advance and employees' withholding tax)			
Initiation Fees		$ 241.00	
Dues, 1946-1947 and Prior Years		3,767.50	
Interest		469.27	
From Publication of Journal			
Advertisements	$4,371.38		
Subscriptions	645.25		
Sale of Journal	84.75		
Sale of Halftones, Electros, etc.	6.13	5,107.51	
Miscellaneous			
Membership Certificates	49.50		
Membership Lists	8.50	58.00	
Total Receipts			$ 9,643.28
Disbursements			
Publication of Journal			
Printing	$2,736.45		
Plates	490.55		
Reporting	354.90		
Stationery and Postage	89.02		
Editor's Salary	500.00		
Sundry	22.68	4,193.60	

General and Administrative			
Certificates of Membership	59.02		
Secretary's Salary	400.00		
Assistant to Secretary—Salary and Clerical Assistance	2,145.00		
Treasurer's Salary	100.00		
Employee's Bonds	93.75		
Printing, Postage and Stationery	843.01		
Office Supplies and Expense	237.41		
Office Rent	1,200.00		
Electricity	79.38		
Telephone and Telegraph	193.40		
Auditing	65.00		
Social Security Taxes	58.03		
Sundry	46.73	5,520.73	
Meetings and Committees			
Water Works School	100.00		
Printing, Postage and Stationery	1,032.48		
Convention Expense	300.58		
Contribution to June Outing	150.00		
Sundry Expense	362.15	1,945.21	
Interest Added to Co-operative Bank Shares		83.25	
Total Disbursements			$11,742.79
Excess of Disbursements over Receipts (exclusive of dues received in advance and employees' withholding tax for current year)			2,099.51
Dues Received in Advance		2,315.00	
Employees' Withholding Tax			
Payment for Prior Year	89.10		
Less Receipts for Current Year	46.24	42.86	2,272.14
Excess of Receipts over Disbursements, Exhibit A			172.63
Balance, General Cash, August 31, 1946		4,627.22	
Less Purchase of Milton Co-operative Bank Shares		300.00	4,327.22
Balance, General Cash, August 31, 1947			
Represented by			
Cash in Second National Bank of Boston		4,449.85	
Cash in Office		50.00	
			$ 4,499.85

ANNUAL REPORT OF THE EDITOR

To the New England Water Works Association:

The Editor submits herewith his report for the year ending August 31, 1947.

As has been customary in the past, the tables of financial figures, accompanying the report, are based upon total charges and accounts receivable, rather than actual cash received and disbursed. A detailed statement of the receipts and disbursements on account of the September and December, 1946, and March and June, 1947, issues of the JOURNAL is included in the report of the Treasurer.

In Table 1 is presented a statement of the material contained in the four issues of the JOURNAL for the past year, while in Table 2 is given a comparison of the JOURNAL for the past year with those for preceding years.

TABLE 1.—STATEMENT OF MATERIAL IN SEPTEMBER AND DECEMBER, 1946, AND MARCH AND JUNE, 1947, ISSUES OF THE JOURNAL OF THE NEW ENGLAND WATER WORKS ASSOCIATION

	Papers	Proceedings	Total text	Index	Advertisements	Cover and contents	Insert plates	Total pages	Total cuts
Sept., 1946	105	4	109	0	42	4	0	155	30
Dec., 1946	64	47	111	8	44	4	0	167	13
Mar., 1947	96	11	107	0	42	4	7	160	15
June, 1947	97	4	101	0	44	4	1	150	20
Total	362	66	428	8	172	16	8	632	78

Size. The four issues contained 632 pages, of which 428 were text.

Cost. The gross cost of the JOURNAL was $4,193.60, equivalent to $4.96 per member; the surplus was $913.91, equivalent to $1.08 per member.

Reprints. Reprints of papers have been furnished to authors at cost.

TABLE 2.—COMPARISONS OF JOURNALS OF THE NEW ENGLAND WATER WORKS ASSOCIATION.
Four Issues for Fiscal Year Ending August 31

	1938	1939	1940	1941[1]	1942[2]	1943[3]	1944	1945	1946	1947
Average edition (copies printed)	1,100	1,100	1,100	1,100	1,100	1,175	1,200	1,200	1,200	1,275
Average membership	785	795	796	800	803	798	799	806	820	846
Circulation at end of year	943	946	967	943	982	969	1,015	1,032	1,042	1,083
Pages of text	510	488	565	540	575	442	442	438	391	428
Pages of text per 1,000 members	650	614	710	675	716	554	553	543	477	516
Total pages, all kinds	699	670	762	733	757	616	621	630	586	632
Total pages per 1,000 members	890	843	957	918	943	772	777	782	715	747
GROSS COST:										
Total	$4,658.05	$4,119.30	$3,846.46	$4,415.00	$4,053.47	$4,234.68	$3,406.48	$3,734.19	$4,053.08	$4,193.60
Per copy	1.06	0.94	0.87	1.00	0.93	0.90	0.71	0.78	0.84	0.82
Per page	6.66	6.15	5.05	5.66	5.36	6.87	5.49	5.83	6.91	6.63
Per member	5.93	5.18	4.33	5.52	5.05	5.31	4.26	4.63	4.94	4.96
Per member per 1,000 pages	8.49	7.13	6.34	7.53	6.67	8.61	6.87	7.35	8.43	7.85
Per member per 1,000 pages of text	11.63	10.61	8.55	10.21	8.78	12.01	9.66	10.57	12.62	11.58
SURPLUS:										
Total	$539.21†	$306.77	$618.37	$276.54†	$534.72†	$609.81†	$407.21	$455.57	$162.33	$913.91
Per copy	0.12†	0.07	0.14	0.06†	0.12†	0.13†	0.08	0.09	0.03	0.18
Per page	0.77†	0.46	0.81	0.38†	0.71†	0.99†	0.66	0.72	0.28	1.44
Per member	0.69†	0.39	0.78	0.35†	0.67†	0.76†	0.51	0.57	0.20	1.08
Per member per 1,000 pages	0.98†	0.58	1.02	0.47†	0.88†	1.24†	0.82	0.90	0.34	1.71
Per member per 1,000 pages of text	1.35†	0.80	1.37	0.64†	1.16†	1.73†	0.92	1.29	0.51	2.52

[1]Including comprehensive index, 1882 to 1939, and 102 pages of standard specifications.
[2]Including 45 pages of standard specifications.
[3]Including 28 pages of standard specifications.
†Net cost.

Circulation. The present circulation of the JOURNAL is:

Members, all grades	865
Subscribers	147
Exchanges	24
Advertisers	47
Total	1,083

JOURNALS have been sent to all subscribers and to advertisers.

Respectfully submitted,

(*Signed*) GEORGE C. HOUSER,
Editor

ANNUAL REPORT OF THE COMMITTE ON LIBRARY

September 16, 1947

To the New England Water Works Association:

Your committee is pleased to report that the Association library has had greater use by the members during the past year than during previous years.

Among the new books added to the library is *Current Water Works Practice* by Maxwell, a book dealing largely with English practice.

Members will be interested in knowing that the Institution of Water Engineers has begun publication of a Journal. *Water and Water Engineering*, formerly the official publication of the Institution, is now published under private auspices.

Additional early reports of historical interest, dealing with New England water works, have been turned over to the Association's library by the Boston Society of Civil Engineers.

Members of the Association are again invited to avail themselves of the library facilities for reference and study.

Respectfully submitted,

(*Signed*) KARL R. KENNISON, *Chairman*
HARRY L. KINSEL

ANNUAL REPORT OF COMMITTEE ON MEMBERSHIP—1947

September 16, 1947

To the New England Water Works Association:

After the officers of the Association were elected for the current year, the President appointed your Chairman of the Committee on Membership, with authority to appoint additional members. It was decided that, rather than to continue to canvass individuals by letter, the method of considering the membership as a Committee of the Whole was preferable.

Accordingly, applications for membership were sent to members of the Association, with the request that they contact persons who might become members of the Association. The results of the canvass for the year are as follows:

	Regular members	Associate members	Corporate members	Total
	NEW MEMBERS			
	94	11	1	106
	Loss of Membership			
Resigned	16	2	1	
Died	15			
Dropped by Executive Committee	1			
Total losses	32	2	1	35
	Net Gains			
	62	9	0	71

Total membership at the date of this report is 897.

Respectfully submitted,

(*Signed*) FRANCIS H. KINGSBURY, *Chairman*

ANNUAL REPORT OF THE FINANCE COMMITTEE

August 30, 1947

To the Executive Committee of the New England Water Works Association

GENTLEMEN:

The Finance Committee submits herewith its report on the budget for the year 1946-1947 and its recommended budget for the year 1947-1948.

The Committee has examined figures obtained from the records of the Association during the past year and has consulted with the Treasurer with reference to probable revenue and expenditures during the coming year.

During the past year the following changes have taken place in the membership roster:

	Resigned	Deaths	Dropped	Additions	Gain
Members	16	15	1	65	33
Corporates	1	0	0	1	
Associates	2	0	0	8	6
	19	15	1	74	39

The above table shows a net gain of 33 members and 6 associates, a total of 39. This growth in membership is about three times what the growth has been each year for the past few years. Because of this increase in membership the revenue from dues during the past year exceeded the budget estimate by about $82.50. Because of good business conditions there is reason to expect a continued rapid growth of membership during the coming year. Your Finance Committee therefore recommends for the year 1947-1948 a budget estimate of $6,400 for the revenue from dues.

Analyses of the records for the closing year are shown in the tables below:

REVENUE FOR 1946-1947

	Budget	Actual to Aug. 30	Difference	
Initiation Fees	$ 150.00	$ 241.00	$ 91.00	balance
Dues	6,000.00	6,082.50	82.50	balance
Interest and Dividends	350.00	469.27	119.27	balance
Journal	4,800.00	5,107.51	307.51	balance
Miscellaneous	125.00	58.00	67.00	deficit
Total	$11,425.00	$11,958.28	$533.28	

EXPENDITURES FOR 1946-1947

	Budget	Actual to Aug. 30	Difference	
General and Administrative	$6,000.00	$5,520.73	$479.27	balance
Publication of Journal	4,500.00	4,193.60	306.40	balance
Meetings and Committees	1,500.00	1,945.21	445.21	deficit
Contingent Fund	500.00	None	500.00	balance
Total	$12,500.00	$11,659.54	$840.46	

It will be noted from the above tables that the actual revenue exceeded the budget estimate by $533.28 and the actual expenditures were less than the budget estimate by $840.46. It will be remembered that your Finance Committee last year recommended, because of rising costs, a budget providing for expenditures amounting to $1,075.00 in excess of revenue. It was suggested that no effort be made to balance the budget during the next year or two and the deficit be drawn from reserves. Your Finance Committee is now happy to report that there has been no deficit. The new schedule of advertising rates was duly put into effect and resulted in an increase in revenue from this source exceeding somewhat the anticipated increase. It is expected that for the coming year the new advertising schedule will result in an increase in revenue of about $1,600.

In preparing the budget for the coming year, the Finance Committee wishes to draw attention to the fact that costs are still rising and have not yet reached a peak. Administrative costs and the cost of publication of the JOURNAL during the past year were less than the budget estimate. Your Committee feels that both of these costs will rise during the coming year and have so provided in the budget.

The recommended budget for the year 1947-1948 is shown in the following tables:

BUDGET FOR 1947-1948, REVENUE

Initiation Fees	$ 200.00
Dues	6,400.00
Interest and Dividends	375.00
Journal	5,800.00
Miscellaneous	75.00
Total	$12,850.00

BUDGET FOR 1947-1948, EXPENDITURES

General and Administrative	$ 6,200.00
Publication of Journal	4,500.00
Meetings and Committees	2,000.00
Contingent Fund	500.00
Total	$13,200.00

It will be noted from the above budget that the Finance Committee again recommends expenditures exceeding revenue. It is again recommended that the deficit, if any, be drawn from the reserves. If the revenue from increased membership and from advertising continues to increase as during the past year, it may be possible to balance the budget eventually without an increase in dues.

The reserve on hand at the close of this fiscal year amounts to $26,243.31. These funds are distributed as shown in the following table:

Checking Account and Petty Cash	$ 4,499.85
Furniture and Fixtures	1,180.00
Bonds	10,000.00
Savings Account	8,068.46
Serial Shares	2,495.00
	$26,243.31

The Finance Committee pointed out last year that the reserve, which has been built up over a period of years, is large enough to warrant the formulation of a policy regarding the purpose of this reserve. There is no apparent need for so large a reserve, inasmuch as the Association should operate on the average on a balanced budget.

It was anticipated last year that rising costs during the coming years might force the Association to consider an increase in dues. This contingency has so far been averted but it may still arise. Your Finance Committee recommends that the Association consider the establishment of a policy whereby the reserve funds are ear-marked to stabilize the dues at their present level.

Respectfully submitted,

(*Signed*) THOMAS R. CAMP, *Chairman*
CHARLES G. RICHARDSON
JAMES A. SWEENEY

ANNUAL REPORT OF THE COMMITTEE ON LEGISLATION

September 16, 1947

To the New England Water Works Association:

Your Committee on Legislation presents the following report on activity in the several State Legislatures in 1947.

No attempt has been made to quote complete laws but rather to summarize or review the principal features of the legislation enacted. The stress on abatement and prevention of pollution of water is noticeable.

The New Hampshire member of the committee, Percy R. Sanders, having passed on, Leonard W. Trager, Director of Sanitary Engineering for the State, kindly reported the important legislation in that State.

Maine

The principal activity in the Maine 1947 Legislature relative to water utilities was the enactment of acts which clear up the question of liability of utilities for street openings. Former law held utilities liable for damage to persons or property forever, even though permits had been paid for and streets repaired by state or city authority. This was found in the case of Larsen vs. New England Telephone & Telegraph Co., September, 1945.

The law was amended so that liability ceases upon completion of repairs to streets or highways by the proper authority (Public Laws, 1947, Chapter 252).

In addition, nine new water districts, ten sewer districts and five combination water and sewer districts were chartered by the State. Some of each provide for entire new systems where none now exist and the remainder provide for the taking over of existing privately- or municipally-owned systems.

New Hampshire

In New Hampshire, House Bill 82, or Chapter 8, Laws of 1947, makes the act relative to Capital Reservice Funds of Towns, Districts, Water Departments and Counties a permanent law.

House Bill 44, or Chapter 5, an amendment to Chapter 72, section 3, Revised Laws, provides for payment of all municipal and county debts in annual payments within 20 years, except that as to bonds or notes issued for the acquisition, reconstruction or enlargement of water works, sewerage and disposal works, and gas or electric plants, the last payment shall be made not later than 30 years after issuance.

Chapter 166, Revised Laws, was amended by Chapter 50, Laws of 1947, and provides penalties for pollution of, or bathing in, public water supplies. Enforcement is placed in the concurrent jurisdiction of local health officers and the state department of health, which is also authorized, by other sections of the law, to require approved changes in sewage treatment. Another section requires approval by the state department of all plans for new, or enlargements of old, water systems, as well as of sewage-disposal systems.

An amendment of section 8, Chapter 165, R.L., requires owners to provide suitable toilets and drains or sewers, for any building leased or occupied by another person.

Vermont

In Vermont, the 1945 law authorizing municipal corporations to organize and conduct water departments and to issue water bonds was amended, so that the issue of bonds under the law would not conflict in any way with the chapter of Vermont laws that governs municipal indebtedness. All bond negotiations carried on between 1945 and 1947 under the 1945 law were validated as if the amended act were in force when such negotiations took place. This amendment clears up legal technicalities that may have existed and makes an offer of Vermont municipal water bonds more attractive to potential buyers.

Act 50 of the 1947 Legislature is an enabling law to permit and promote the construction of sewage-treatment plants. "Sewage", as defined, includes garbage and industrial wastes. The law is somewhat

similar to the water-system enabling law of 1945 and provides for the taking of lands and for construction, operation and maintenance of complete systems. Sewer service charges may be established and shall be a lien on real estate. Sewage-disposal bonds shall be considered outside the debt limit.

A companion law enables a municipal corporation to construct, maintain, operate and repair a sewer system (exclusive of sewage-treatment plant). All features of the law are practically the same as in the enabling law for treatment plants.

The 1947 Legislature established a Vermont State Water Conservation Board to protect, regulate and control the water resources, exclusive of municipal water supplies, which are under general supervision of the State Board of Health. The Water Board will coöperate with federal agencies and adjoining States in all matters relating to interstate streams and in matters of federal aid for sewage-treatment facilities. The new board shall coöperate with the State Board of Health in matters of stream pollution.

Perhaps of particular interest to water-works men is the increased appropriation to the Public Health Department, so that the work of the Sanitary Engineering and Laboratory Divisions could be expanded and better service rendered to water departments and other municipal problems.

Massachusetts

In Massachusetts, House Bill 1761 was enacted as Chapter 148, Acts of 1947. This act authorizes local Boards of Health to prevent the use of unsafe water supplies in places of habitation and in places where the public is served food or drink.

House Bill 424 was enacted, to require recording of certificates of dissolution of water liens by the officials recording the original liens. The charge for recording of the dissolution is to be added to the amount of the lien.

House Bill 1566 was referred to the next annual session. This bill proposed that the cities and towns supplied by the Boston Metropolitan District Water System should reduce their rates in proportion to the reduction in charges by the District Water Supply Commission.

House Bill 24, presented by Tax Commissioner Long, proposed

that 5% of water receipts be paid into the general funds of the municipality. This bill also was referred to the next annual session.

Rhode Island

In Rhode Island the General Assembly enacted several laws dealing with pollution of water.

Chapter 1836 authorizes the assessment of charges for the use of sewerage systems and sewage-disposal facilities, the receipts to be ear-marked for the operation, maintenance and expansion of such works.

Chapter 1837 provides for the construction and operation of a Blackstone Valley Sewer District project. If so voted by the electorate, funds will be provided and a commission appointed with authority to construct and to maintain the project. The Commission will assess charges in order that the project may be self-liquidating.

Chapter 1838 approves the execution of a compact with the other New England States for the control of future pollution and the abatement of existing pollution of interstate waters in the New England area.

Connecticut

The water authorities in Connecticut, banded together, employ counsel to represent them in favoring or opposing proposed legislation. Possibly because of the fact that there are numerous water companies, in distinction from municipally operated utilities, much legislation is proposed for regulating their operations in one manner or another. The counsel employed, however, seems to be quite efficient in controlling or, at least, moderating the action taken.

Respectfully submitted,

(*Signed*) ARTHUR C. KING, *Chairman*
SIDNEY S. ANTHONY
THEODORE L. BRISTOL
WALTER C. CONROY
PHILIP J. HOLTON, JR.
EDWARD L. TRACY

ANNUAL REPORT OF COMMITTEE ON COMMITTEES—1947

To the New England Water Works Association:

This committee, appointed by the Executive Committee of the Association to promote coördination of committee activities in the Association and to promote the establishment of new technical committees where this seems advisable, submits a brief report. Our committee has followed its usual practice of communicating with the various committee chairmen to ascertain their ideas as to continuance of committees and their plans with regard to reports. We have also checked up during the year with other associations regarding joint committees. The Program Committee has been advised as to those committees desiring to submit reports at the annual meeting. Committee work was greatly curtailed during the war years and increased committee activity is hoped for. Inactive committees should be eliminated so far as possible but some committees dealing with preparation or approval of standards and specifications are subject to limitations and others serve to represent the Association in fields where changes are under consideration.

During the past year no new committees were appointed by the Executive Committee. Some changes were made, as usual, in committee membership, as noted in the December, 1946, JOURNAL of the Association.

The following committees will either submit progress reports or, in the opinion of this committee, should be continued:

Committee on Technical Program.
Committee on Finance.
Committee on Membership.
Committee on Library.
Committee on Legislation.
Committee on Committees.
Committee on Reciprocal Relations with the Institution of Water Engineers.

Committee on Classification of Water Works Employees and Salaries.
Committee on Survey of Ground Water Supplies in New England.
Committee on Rainfall and Yield of Drainage Areas.
Committee on Distribution System Safety. (Joint Committee with A.W.W.A.)
Committee on Cathodic Protection of Steel Tanks and Standpipes.
Committee on Coëfficients for Friction in Pipe Lines.
Committee to Investigate Grounding. (Coöperating with the American Research Committee on Grounding.)
Committee to Report on Developments in Water Quality Standards.
Committee on Water Quality Tolerances for Industrial Uses.
Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation.
Committee on Specifications for Cast-Iron Pipe and Special Castings. (Sectional Committee under A.S.A.)
Committee on Reinforced Concrete Pressure Pipe. (Joint Committee with A.W.W.A.)
Committee on Code for Pressure Piping. (Joint Committee with A.S.M.E.)
Committee on Laying Cast-Iron Pipe. (Joint Committee with A.W.W.A.)
Committee on Specifications for Steel Pipe. (Joint Committee with A.W.W.A.)
Committee on Standardization of Pipe Flanges and Fittings. (Sectional Committee under A.S.A.)
Committee on Valve Box Frames and Covers. (Joint Committee with A.W.W.A.)
Committee on Meter Specifications. (Joint Committee with A.W.W.A.)
Committee on Hydrant Specifications. (Joint Committee with A.W.W.A.)
Committee on Gate Valves. (Joint Committee with A.W.W.A.)
Committee on Sluice Gates. (Coöperating with Committee of A.W.W.A.)

Discontinuance of Committees

Chairmen of the following committees have suggested that their committees be discontinued:

Committee on Survival and Retirement Experience with Water Works Facilities. (Joint Committee with A.W.W.A.)

Committee on Threads for Underground Service Lines. (Joint Committee with A.W.W.A.)

Committee on Water and Sewage Works Development. (Joint Committee with A.W.W.A.)

Committee on Steel Standpipes and Elevated Tanks. (Joint Committee with A.W.W.A.)

It is suggested that the Association secretary consult with the secretary of the American Water Works Association as to the status of these committees and, unless there is good reason to the contrary, that they be discontinued.

The chairman of the Committee on Meter Specifications has suggested that possibly this committee might be discontinued but some consideration is being given to further studies in this field, so that decision as to discontinuance should be made only after consultation with the committee chairman. We have, therefore, continued to list this committee.

New Committees

A suggestion has been made to our committee that, because of the problems arising in the field of labor-management relations, some study should be undertaken by the Association. If an interested committee membership can be assembled to represent both municipally owned and privately owned water works, the appointment of such a committee would appear worth-while.

Despite the fact that, to the best of our knowledge, the Executive Committee has taken no specific action in favor of our previous recommendation, we again recommend that a committee be designated to report to the Executive Committee on a program of public education in the water-supply field, either through paid expert service or in some other way. Other associations are finding that such activities pay dividends in public good-will and support.

Other Committee Activities

The Committee to Report on Developments in Water Quality Standards, through its chairman, suggests that the committee be given authority to confer with a similar committee of the American Public Health Association and such action by the Executive Committee is recommended.

Conclusions and Recommendations

It is recommended that the standing committees listed above be re-appointed and that the discontinuance of several other committees, listed separately, be considered. Other recommendations as to new committees and committee activities are discussed and should in our opinion be adopted.

Respectfully submitted,

(*Signed*) WARREN J. SCOTT, *Chairman*
HARRY U. FULLER
ARTHUR C. KING
EARL R. PERRY
WILLIAM E. STANLEY

ANNUAL REPORT OF THE COMMITTEE ON RECIPROCAL RELATIONS WITH THE INSTITUTION OF WATER ENGINEERS

September 16, 1947

To the New England Water Works Association:

Early this year the Institution of Water Engineers requested the submission of the best of recent papers published in the JOURNAL for consideration by a corresponding Committee of the Institution. From these papers and that presented to the Institution in 1945 by Past-President Karl R. Kennison one paper is to be chosen to merit the award of the Diploma, provided for in the agreement reached just prior to the beginning of the Second World War in 1939.

Your Committee submitted the papers which received the Dexter Brackett Award for the years 1941, 1942, 1943, 1944 and 1945, respectively. As yet no word has been received as to what selection has been made by the Institution.

It is the intention of your Committee to request next year a similar list from the Institution, in order that the New England Water Works Association may reciprocate in awarding a Diploma to a member of the Institution.

Your Committee also wishes to call attention to a change in name and scope of the Institution's Committee, as described in the following excerpt from the Presidential Address of Brian Lonsdale McMillan at Birmingham on May 28, 1947:

"A new Institution Committee, the International Relations Committee, was set up during the past year to take the place of the old New England Water Works Committee, which had maintained contact for many years with the New England Water Works Association in the U. S. A. It is intended to make and maintain contact with as many as possible of the overseas professional Institutions or Associations concerning Water Engineering and to welcome and entertain their members visiting this country. Those of our members who have

contacts with overseas water engineers are requested to inform the Secretary when suitable opportunities occur of furthering the objects of this Committee."

Respectfully submitted,

(*Signed*) E. SHERMAN CHASE, *Chairman*
LELAND G. CARLTON
PERCY A. SHAW

PROGRESS REPORT OF THE COMMITTEE ON GATE VALVES

September 10, 1947

To the New England Water Works Association:

Your Committee on Gate Valves held a meeting at Springfield, Mass., the latter part of June, to consider suggestions for the revision of the present specifications, submitted by F. A. Randlett (R. W. Hunt Co., Chicago), Chairman of the Joint Committee of the A.W.W.A. and N.E.W.W.A. for the Revision of the Present Gate Valve Specifications, and to study a draft of the revised specifications, prepared by Vance C. Lischer (Horner & Shifrin, St. Louis) for presentation to the Joint Committee at the A.W.W.A. Convention in San Francisco in July.

With the assistance of Donald Belcher of the Chapman Valve Manufacturing Co., a written discussion of the proposed revision of the present specifications was prepared and forwarded to Mr. Randlett for consideration at the Joint Committee meeting.

No report on the San Francisco meeting of the Joint Committee is available as yet but it was the hope of the chairman and members of the Joint Committee, prior to the A.W.W.A. Convention, that their job might be completed within the next year. It is suggested that this be accepted as a progress report and that your Committee be continued for another year.

Respectfully submitted,

(*Signed*) WALTON H. SEARS
LELAND G. CARLTON
HAROLD W. GRISWOLD, *Chairman*

PROGRESS REPORT OF THE HYDRANT SPECIFICATION COMMITTEE

To the New England Water Works Association:

The Hydrant Specification Committee of the New England Water Works Association wishes to report that we have no recommendations at the present moment to make in regard to the revision of the hydrant specifications.

We would suggest that the committee be continued for one year.

Respectfully submitted,

(*Signed*) HARRY U. FULLER
HAROLD W. GRISWOLD
ROGER W. ESTY, *Chairman*

PROGRESS REPORT OF THE COMMITTEE ON LAYING CAST-IRON PIPE

To the New England Water Works Association:

At the 1945 annual meeting your Committee, appointed to co-operate with the American Water Works Association in revision of its Specifications for Laying Cast-Iron Pipe, reported that the specifications had been reviewed and suggested revisions submitted to the A.W.W.A. Committee for consideration.

Your Committee has little further to report at this time. It is understood that the A.W.W.A. has adopted the recommendations of Mr. Calvert's sub-committee, "Recommended Procedure for Disinfecting Water Mains", but final action has not been taken by the A.W.W.A. regarding the Standard Specifications for Laying Cast-Iron Pipe. When such action has been taken, a further report will be made.

Respectfully submitted,

(*Signed*) W. S. MARINER, *Chairman*
GEORGE W. COFFIN

PROGRESS REPORT OF COMMITTEE ON SPECIFICATIONS FOR CAST-IRON PIPE AND FITTINGS

To the New England Water Works Association:

Committee A21 of the American Standards Association, on which your Association is represented by the undersigned, has resumed activity following a relatively quiescent period during the war. There have been meetings in New York of the main committee, its executive committee and the several technical committees during the past few months, in the hope of producing final drafts of the several specifications remaining to be finished at an early date.

Unfortunately it has developed that in the long interim there have been marked changes in point of view among some of the members, particularly the producers, with regard to certain details that were thought to have been settled but which are now again thrown open for discussion. Nevertheless, some progress has been made and there is reason to hope that, during the coming year, specifications will emerge for Cast-Iron Pipe other than Pit-Cast. There may be some requirements for bursting tests.

The specification for Cement-Mortar Lining (A21.4) will doubtless be revised, as the result of experience since its first issue, but there is grave doubt whether agreement can be reached on Tar Dip Coating, the specification for which has never passed the tentative stage.

Substantial progress has been made toward the completion of specifications for Short-Body Fittings, which will be issued as A21.10 upon completion of a current study of basic fitting design and comparison of relative dimensions to assure consistency in the various sizes.

It is recommended that the representation of N.E.W.W.A. on A.S.A. Committee A21 be continued.

Yours respectfully,

(*Signed*) ELSON T. KILLAM
ARTHUR L. SHAW

PROGRESS REPORT OF THE COMMITTEE ON METER SPECIFICATIONS

September 16, 1947

To the New England Water Works Association:

The last progress report of this Committee was presented on September 10, 1945, at which time it was stated that the specifications covering Current and Compound Meters were practically in final form and nearly ready for presentation to the A.W.W.A. Practice Committee and to the membership of the N.E.W.W.A. for action by these respective associations.

Subsequent to that time an inconsistency was discovered in the two specifications, in that they were not in agreement as to their operating capacity head-loss characteristics. This led to a revision of the specifications which have now, as revised, been advanced to the status of Standard Specifications by the A.W.W.A.

In addition, committees of both Associations have agreed upon a Fire Service Meter Specification, which raises the accuracy requirements at Minimum Test Flows from 90 to 95% and narrows the gap between the beginning of the "Change-Over Point", where the accuracy of registration falls below 97% due to operation of the automatic valve mechanism, and the end of the "Change-Over Point", where accuracy of registration again reaches 97%.

These specifications are to be published in the September, 1947, issue of the N.E.W.W.A. JOURNAL, subsequent to which, and after due notice to the membership, the Association will be requested to take proper action toward the adoption of same as standards for this Association.

While this will complete the original conception of the Committee's work, the A.W.W.A. Committee has decided to proceed further and to create a specification for Current Type Propeller-Driven Meters. The first draft of this specification has been prepared and

is now before both the N.E.W.W.A. and A.W.W.A. Committees for their review.

Unless instructed to the contrary, your Committee will continue to coöperate with that of the A.W.W.A. in the development of a satisfactory specification for this fifth type of meter.

Respectfully submitted,

(*Signed*) RICHARD H. ELLIS, *Chairman*

*COMMITTEES OF THE NEW ENGLAND WATER WORKS ASSOCIATION 1947 - 1948

N.E.W.W.A.—1. Committee on Technical Program: Stanley M. Dore, *Chairman,* George G. Bogren, William B. Duffy, Gordon M. Fair, George C. Houser, Paul F. Howard, Thomas E. Kennedy, Truman H. Safford and Marshall S. Wellington.

N.E.W.W.A.—2. Committee on Northern New England Meeting: Clarence E. Ferry.

N.E.W.W.A.—3. Committee on Southern New England Meeting: Philip J. Holton, Jr.

N.E.W.W.A.—4. Committee on Finance: Walter B. Bushway, *Chairman,* Walter C. Conroy and John B. Kennedy.

N.E.W.W.A.—5. Committee on Membership: Francis H. Kingsbury, *Chairman,* Charles J. Crump, F. Edward Driscoll, Frank J. Driscoll, Howard C. Mandell, William J. C. Marshall, Howard H. Potter, James A. Sweeney, Ellis A. Tarlton, Edward L. Tracy and James V. Turner.

N.E.W.W.A.—6. Committee on Library: Karl R. Kennison, *Chairman,* and Harry L. Kinsel.

N.E.W.W.A.—7. Committee on Committees: Warren J. Scott, *Chairman,* Harry U. Fuller, Arthur C. King, Earl R. Perry and William E. Stanley.

N.E.W.W.A.—8. Committee on Legislation: Arthur C. King, *Chairman,* Theodore L. Bristol, Walter C. Conroy, Philip J. Holton, Jr., G. Arthur Faneuf, Harry U. Fuller, Roger G. Oakman and Edward L. Tracy.

N.E.W.W.A.—9. Committee on Reciprocal Relations with the Institution of Water Engineers (England): E. Sherman Chase, *Chairman,* Leland G. Carlton and Percy A. Shaw.

N.E.W.W.A.—10. Committee on Classification of Water Works Employees and Salaries: Walter B. Bushway, *Chairman,* Albert E. Casey, Walter C. Conroy, Roger G. Oakman and Allen M. Symonds.

N.E.W.W.A.—11. Committee on Survey of Ground Water Supplies in New England: Leslie K. Sherman, *Chairman,* M. L. Brashears, William A. Healy, Vincent M. Hynes, Howard H. Potter, Walter J. Shea and Edward L. Tracy.

N.E.W.W.A.—12. Committee on Rainfall and Yield of Drainage Areas: Arthur D. Weston, *Chairman,* Harold K. Barrows, Allan T. Gifford, Peter C. Karalekas, Francis H. Kingsbury, Harvey B. Kinnison, Arthur T. Safford, Caleb M. Saville, Ralph M. Soule, Miner R. Stackpole and Howard M. Turner.

N.E.W.W.A.—13. Committee on Distribution System Safety: William E. Stanley, *Chairman,* Donald C. Calderwood and Frank A. Marston.

N.E.W.W.A.—15. Committee on Cathodic Protection of Steel Tanks and Standpipes: Howard E. Bailey, *Chairman,* Sidney S. Anthony, Donald C. Calderwood, Richard H. Ellis, Harry U. Fuller, Madison H. Goff and William P. Melley.

N.E.W.W.A.—16. Committee on Coefficients for Friction in Pipe Lines: Elson T. Killam, *Chairman,* William W. Brush, E. Shaw Cole and F. W. Haley.

N.E.W.W.A.—17. Committee to Investigate Grounding (Cooperating with the American Research Committee on Grounding): George A. Sampson, *Chairman,* Warren A. Gentner, Arthur V. Harrington and Edward E. Minor.

N.E.W.W.A.—18. Committee to Report on Developments in Water Quality Standards: Arthur D. Weston, *Chairman,* Almon L. Fales and Edward W. Moore.

N.E.W.W.A.—19. Committee on Water Quality Tolerances for Industrial Uses: Edward W. Moore, *Chairman,* Stuart E. Coburn, Louis A. Olney, George A. Sampson and Hervey J. Skinner.

N.E.W.W.A.—20. Committee to Report on Developments in Our Knowledge of Corrosion and Its Mitigation: Edward W. Moore, *Chairman,* Lazarus Rubin and Walton H. Sears.

N.E.W.W.A.—21. Committee on Specifications for Cast-Iron Pipe and Fittings (Sectional Committee under American Standards Association): Elson T. Killam and Arthur L. Shaw.

N.E.W.W.A.—22. Committee on Reinforced Concrete Pressure Pipe (Joint with American Water Works Association): Stanley M. Dore, *Chairman,* and George A. Sampson.

N.E.W.W.A.—23. Committee on Code for Pressure Piping (Joint with American Society of Mechanical Engineers): Thomas F. Wolfe.

N.E.W.W.A.—24. Committee on Laying Cast-Iron Pipe (Joint with American Water Works Association): W. S. Mariner, *Chairman,* and George W. Coffin.

N.E.W.W.A.—25. Committee on Specifications for Steel Pipe (Joint with American Water Works Association): Stanley M. Dore and Scott Keith.

N.E.W.W.A.—26. Committee on Standardization of Pipe Flanges and Fittings (Sectional Committee under American Standards Association): Elson T. Killam.

N.E.W.W.A.—27. Committee on Threads for Underground Service Line Fittings (Joint with American Water Works Association): William W. Brush, *Chairman,* and Donald C. Calderwood.

N.E.W.W.A.—28. Committee on Steel Standpipes and Elevated Tanks (Joint with American Water Works Association): George A. Sampson, *Chairman,* Howard E. Bailey, Harry U. Fuller and Henry E. Halpin.

N.E.W.W.A.—29. Committee on Valve Box Frames and Covers (Joint with American Water Works Association): Sidney S. Anthony, *Chairman,* and Scott Keith.

N.E.W.W.A.—30. Committee on Meter Specifications (Joint with American Water Works Association): Richard H. Ellis, *Chairman,* Warren A. Gentner and Dwight H. Hall.

N.E.W.W.A.—31. Committee on Hydrant Specifications (Joint with American Water Works Association): Roger W. Esty, *Chairman,* Harry U. Fuller and Harold W. Griswold.

N.E.W.W.A.—32. Committee on Gate Valves (Joint with American Water Works Association): Harold W. Griswold, *Chairman,* Leland G. Carlton and Walton H. Sears.

N.E.W.W.A.—33. Committee on Sluice Gates (Cooperating with Committee of American Water Works Association): Elson T. Killam, *Chairman,* and Harold W. Griswold.

Tentative

Standard Specifications

for

THREADS FOR UNDERGROUND SERVICE LINE FITTINGS

These "Tentative Standard Specifications for Threads for Underground Service Line Fittings" are based upon a study of patterns for service line fittings now used widely in the water works field in North America. Should a purchaser wish to standardize his purchases in accordance with the dimensions given herein, he may do so by referring the manufacturer to this document (7T.1–7) and by naming the item or items he wishes to purchase.

Manufacturers are expressly advised that the term "A.W.W.A. Standard Threads for Service Line Fittings" can be applied only to fittings which conform to the dimensions herein.

American Water Works Association

Approved as Tentative by the Board of Directors of the A.W.W.A. on July 25, 1947

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AMERICAN WATER WORKS ASSOCIATION

Incorporated

500 Fifth Avenue, New York 18, N. Y.

Foreword

The development of standards for threads for underground service line fittings was undertaken by the American Standards Association in 1929 and a subcommittee to develop such standards was appointed. This subcommittee developed proposed threads which were embodied in two drawings submitted by the subcommittee as the proposed standards. In 1932, the subcommittee reported that it believed its work had been completed and asked to be discharged. No action was taken by the American Standards Association on these proposed threads.

The need of standards for threads was recognized by the American Water Works Association and the appointment of a committee to recommend such standards was authorized in 1940. Although preliminary work was carried on by this committee, World War II made it advisable to stop such work until the summer of 1945. The membership of Committee 7T was then revised, with a member being appointed to represent virtually each of the A.W.W.A. Sections and W. H. Gourlie, Hartford, Conn., was appointed as technical consultant to the committee.

Through the co-operation of the manufacturers of these fittings, knowledge of current practices used for such threads was secured. Threads that represented current practice, as nearly as practicable, were set up for those fittings for which any substantial demand existed in the water works field.

No recommended standards have been set up for those threads which, on an annual production basis, represent only approximately 5 per cent or less of fittings called for by water works plants.

Also, no threads are included for service lines smaller than the ¾-in. size, as this size is the smallest approved by the Association.

The New England Water Works Association also appointed a committee on establishing standard threads for underground fittings and the committees of these two associations have co-operated closely in the work of setting up the recommended standards.

The setting up of standards has been limited to the threads, and the standards do not cover any other part of the underground service line fittings.

These standards have been submitted to the A.W.W.A. Board of Directors and were approved as Tentative on July 25, 1947.

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Tentative Standard Specifications for 7T.1-T

Threads for Underground Service Line Fittings

Section 1–1—General

Sec. 1–1. The fittings covered by these specifications are those in general use in the water works field for the installation of corporation stops in water mains and the service pipe extending from the main into the customer's premises up to the building stop.

Section 1–2—Description of Threads

Sec. 1–2.1—Drawings

2.1.1. All dimensions of threads shall be in accordance with the details given in Fig. 1–9, which form a part of these specifications.

2.1.2. The profiles shown in drawings are pictorial only, and producer's standards are to be furnished unless otherwise specified by the purchaser.

Sec. 1–2.2—Design Standards

2.2.1. The thread form shall be the same as that used on American National Taper Pipe Threads as approved by the American Standards Association, December 1945, and designated as ASA–B2.1–1945.

2.2.2. All starting threads shall be chamfered in accordance with the manufacturer's standard practice.

2.2.3. Thread forms for all straight threads in copper and lead services (Fig. 2–8) shall be in accordance with American National standards, with tolerances approximating Class 2, and allowances as indicated.

2.2.4. Wherever tapered iron pipe threads are called for, they shall conform to American Standard ASA–B2.1–1945.

2.2.5. A number of other fittings are used in underground water service, such as adapters for changing from lead service to copper service, copper service to iron pipe, and so on. Such fittings shall be furnished with threads made in accordance with the standard established for each service. No separate drawings of these threads are included in this standard.

2.2.6. If the purchaser specifies a wood screw thread on the inlet end of the corporation stop, it shall be made in accordance with the producer's standards.

2.2.7. On corporation stops, any plain extension at the inlet end shall be in addition to the thread length *L* as shown on Fig. 1.

2.2.8. The standard corporation stop thread shown in Fig. 1 is the one most extensively used on the inlet end of the corporation stop in American water works practice.*

2.2.9. In gaging A.W.W.A. standard thread, the thread is within tolerances when the gaging face is within one turn of being flush with the end of the thread.

2.2.10. If the purchaser specifies that the corporation stop furnished shall be finished with a tapered iron pipe thread, this thread shall conform to ASA–B2.1–1945 (as stated in Sec. 1–2.2.4 of these specifications), with the extra thread added at the large end of the corporation stop.

* This thread is commonly known to the trade as the Mueller Thread.

TABLE 1

Standard Corporation Stop Thread

Nominal Size	Threads per inch	Taper per foot	Diameters at Small End			Length *L* (min.)
			Major	Pitch	Minor	
in.		*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	14	$1\frac{3}{4}$	1.104	1.047	0.990	$1\frac{1}{4}$
1	12	$1\frac{3}{4}$	1.332	1.265	1.198	$1\frac{3}{16}$
$1\frac{1}{4}$	$11\frac{1}{2}$	1	1.728	1.658	1.588	$1\frac{3}{8}$
$1\frac{1}{2}$	$11\frac{1}{2}$	1	2.004	1.934	1.864	$1\frac{1}{2}$
2	$11\frac{1}{2}$	1	2.577	2.507	2.437	$1\frac{17}{32}$

This thread is for use on the inlet end.

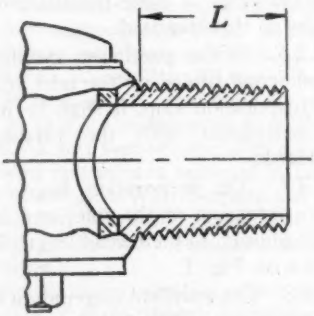

FIG. 1. Standard Corporation Stop Thread

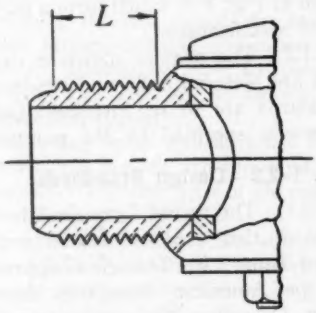

FIG. 2. Fitting Thread for Use With Flared Copper Service Tubes, Type K

TABLE 2

Fitting Thread for Use With Flared Copper Service Tubes, Type K

Nominal Size	Threads per inch	Major		Pitch		Minor Diam. (max.)	Length *L* (min.)
		Diam.	Tol.	Diam.	Tol.		
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	14	1.259	−0.010	1.213	−0.006	1.171	$\frac{5}{8}$
1	$11\frac{1}{2}$	1.593	−0.015	1.536	−0.008	1.486	$\frac{3}{4}$
$1\frac{1}{4}$	$11\frac{1}{2}$	2.055	−0.015	1.998	−0.008	1.948	1
$1\frac{1}{2}$	$11\frac{1}{2}$	2.465	−0.015	2.408	−0.008	2.358	$1\frac{1}{16}$
2	$11\frac{1}{2}$	3.185	−0.015	3.128	−0.008	3.078	$1\frac{5}{16}$

External thread is designed for the external coupling threads of corporation stops, curb stops and adapters for use with flared copper service tubes, Type K.

Internal driving thread shall be provided in copper service corporation stops only when so specified. Such threads shall conform to Fig. 8.

TABLE 3

Coupling Nut for Use With Flared Copper Service Tubes, Type K

Nominal Size	Threads per inch	Major Diam. (min.)	Pitch		Minor		Length *L* (min.)
			Diam.	Tol.	Diam.	Tol.	
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	14	1.266	1.220	+0.006	1.189	+0.008	$\frac{1}{2}$
1	$11\frac{1}{2}$	1.603	1.546	+0.008	1.509	+0.010	$\frac{3}{4}$
$1\frac{1}{4}$	$11\frac{1}{2}$	2.065	2.008	+0.008	1.971	+0.010	1
$1\frac{1}{2}$	$11\frac{1}{2}$	2.475	2.418	+0.008	2.381	+0.010	$1\frac{1}{16}$
2	$11\frac{1}{2}$	3.195	3.138	+0.008	3.101	+0.010	$1\frac{1}{16}$

This thread is designed for all internal threads in fittings for use with flared copper service tubes, Type K.

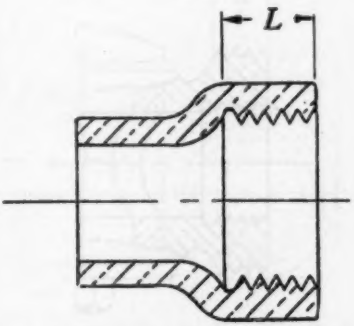

FIG. 3. Coupling Nut for Use With Flared Copper Service Tubes, Type K

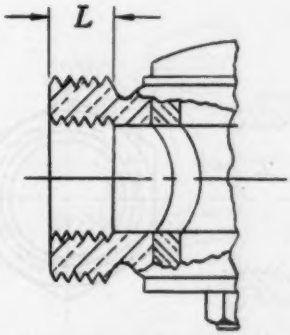

FIG. 4. Fitting Thread for Use With Extra Strong Lead Flanged Pipe

TABLE 4

Fitting Thread for Use With Extra Strong Lead Flanged Pipe

Nominal Size	Threads per inch	Major		Pitch		Minor Diam. (max.)	Length *L* (min.)
		Diam.	Tol.	Diam.	Tol.		
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	12	1.843	−0.015	1.789	−0.008	1.741	$\frac{1}{2}$
1	12	2.158	−0.015	2.104	−0.008	2.056	$\frac{9}{16}$
$1\frac{1}{4}$	10	2.526	−0.015	2.461	−0.011	2.403	$\frac{5}{8}$
$1\frac{1}{2}$	10	2.794	−0.015	2.729	−0.011	2.671	$\frac{11}{16}$
2	10	3.357	−0.015	3.292	−0.011	3.234	$\frac{3}{4}$

External thread is designed for corporation stops, curb stops, and fittings used with extra strong lead flanged pipe.

Internal thread for driving is for corporation stops only and shall conform to Fig. 8.

TABLE 5

Coupling Nut for Use With Extra Strong Lead Flanged Pipe

Nominal Size	Threads per inch	Major Diam. (min.)	Pitch		Minor		Length *L* (min.)
			Diam.	Tol.	Diam.	Tol.	
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	12	1.853	1.799	+0.008	1.763	+0.009	$\frac{11}{16}$
1	12	2.168	2.114	+0.008	2.078	+0.009	$\frac{13}{16}$
$1\frac{1}{4}$	10	2.536	2.471	+0.011	2.428	+0.010	$\frac{15}{16}$
$1\frac{1}{2}$	10	2.804	2.739	+0.011	2.696	+0.010	1
2	10	3.367	3.302	+0.011	3.259	+0.010	$1\frac{1}{16}$

This thread is designed for coupling nuts used with extra strong lead flanged pipe.

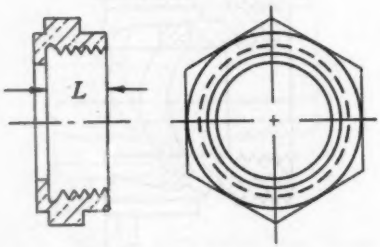

FIG. 5. Coupling Nut for Use With Extra Strong Lead Flanged Pipe

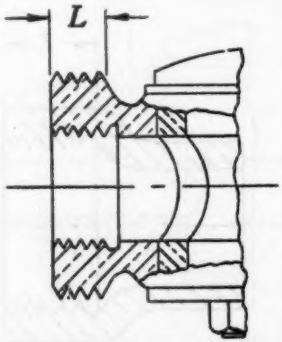

FIG. 6. Fitting Thread for Use With Double Extra Strong Lead Flanged Pipe

TABLE 6

Fitting Thread for Use With Double Extra Strong Lead Flanged Pipe

Nominal Size	Threads per inch	Major		Pitch		Minor Diam. (max.)	Length *L* (min.)
		Diam.	Tol.	Diam.	Tol.		
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	12	2.030	−0.015	1.976	−0.008	1.928	$\frac{1}{2}$
1	12	2.323	−0.015	2.269	−0.008	2.221	$\frac{9}{16}$
$1\frac{1}{4}$	10	2.639	−0.015	2.575	−0.011	2.516	$\frac{5}{8}$
$1\frac{1}{2}$	10	3.070	−0.015	3.006	−0.011	2.947	$\frac{11}{16}$
2	10	3.556	−0.015	3.492	−0.011	3.433	$\frac{3}{4}$

External thread is designed for corporation stops, curb stops and fittings used with double extra strong lead flanged pipe.

Internal thread for driving is for corporation stops only and shall conform to Fig. 8.

TABLE 7

Coupling Nut for Use With Double Extra Strong Lead Flanged Pipe

Nominal Size	Threads per inch	Major Diam. (min.)	Pitch		Minor		Length *L* (min.)
			Diam.	Tol.	Diam.	Tol.	
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	12	2.040	1.986	+0.008	1.950	+0.009	$\frac{11}{16}$
1	12	2.333	2.279	+0.008	2.243	+0.009	$\frac{11}{16}$
$1\frac{1}{4}$	10	2.649	2.585	+0.011	2.541	+0.010	$\frac{11}{16}$
$1\frac{1}{2}$	10	3.080	3.016	+0.011	2.972	+0.010	1
2	10	3.566	3.502	+0.011	3.458	+0.010	$1\frac{1}{16}$

This thread is designed for coupling nuts used with double extra strong lead flanged pipe.

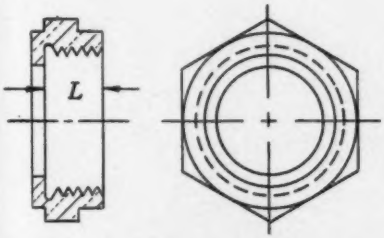

FIG. 7. Coupling Nut for Use With Double Extra Strong Lead Flanged Pipe

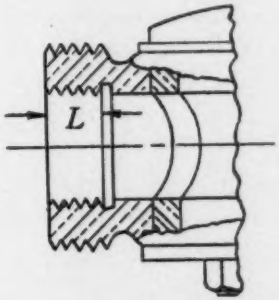

FIG. 8. Internal Driving Thread for Corporation Stops

TABLE 8

Internal Driving Thread for Corporation Stops

Nominal Size	Threads per inch	Major Diam. (min.)	Pitch		Minor		Length *L* (min.)
			Diam.	Tol.	Diam.	Tol.	
in.		*in.*	*in.*	*in.*	*in.*	*in.*	*in.*
$\frac{3}{4}$	12	0.855	0.801	+0.006	0.765	+0.009	$\frac{1}{2}$
1	12	1.089	1.035	+0.006	0.999	+0.009	$\frac{11}{16}$
$1\frac{1}{4}$	10	1.374	1.309	+0.010	1.266	+0.011	$\frac{13}{16}$
$1\frac{1}{2}$	8	1.666	1.585	+0.010	1.531	+0.014	1
2	8	2.165	2.084	+0.010	2.030	+0.014	$1\frac{1}{4}$

This internal driving thread is designed for all types of corporation stops.

TABLE 9

Tapered Iron Pipe Thread for Outlet End of Corporation Stops

Nominal Size	Pipe Thread	
	Size	Threads per inch
in.	*in.*	
$\frac{3}{4}$	1	11½ NPT
1	1¼	11½ NPT
1¼	1½	11½ NPT
1½	2	11½ NPT
2	2½	8 NPT

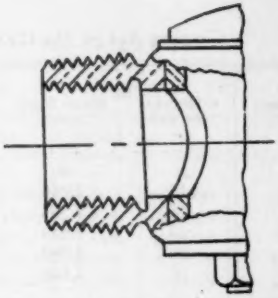

FIG. 9. Tapered Iron Pipe Thread for Outlet End of Corporation Stops

American National Taper Pipe Thread one size larger than nominal is used on outlet end of corporation stops when connection is to iron pipe service.

Internal thread is for driving and shall conform to Fig. 8.